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POLLUTION PREVENTION IN AIR FORCE SYSTEM ACQUISITION PROGRAMS

by

Roy K. Salomon

A Dissertation, submitted to the faculty of The University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Environmental Sciences and Engineering in the Department of Environmental Sciences and Engineering.

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Pollution Prevention in Air Force System Acquisition Programs
(Under the direction of Deborah Amaral.)

ABSTRACT

Neither the Air Force nor the Department of Defense has instituted a comprehensive pollution-prevention policy for its system acquisition programs. This research employs an embedded case study to examine pollution prevention implementation within the overall Air Force systems acquisition framework and involves several units of analysis. The main unit is the acquisition process as a whole. The subunits include four aerospace contractors that are involved in major acquisition programs. The companies studied are Lockheed Aeronautical Systems Company, Lockheed Fort Worth Company, McDonnell Douglas Aerospace - East, and Pratt & Whitney's Government Engines and Space Propulsion unit. Individual case studies of the subunits are included and are used to address the overall acquisition process.

In addressing the overall process, pollution prevention implementation in the aerospace industry is described first. The global case study describes and compares the companies' pollution prevention objectives, strategies, and policies; pollution prevention paradigms, contextual factors, and pollution prevention program implementation. Next, a pollution prevention implementation framework is developed and evaluated as a means for integrating pollution prevention, environmental impact analysis, and system engineering and design in the systems acquisition process. The framework helps demonstrate the need for a system of pollution prevention analysis in addition to environmental impact analysis. Finally, three broad DoD-level policy issues that were identified in the case study are examined and recommendations for changing DoD policy are made.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure **Page**

LIST OF TABLES

LIST OF ABBREVIATIONS

α	type I error
β	type II error
π_1	probability for case 1
π_2	probability for case 2
Admin	administrative
AF	Air Force
AFB	Air Force Base
AFOSH	Air Force Occupational Safety and Health
AFP	Air Force Plant
AIA	Aerospace Industries Association
ARACT	alternate reasonably available control technology
ASC	Aeronautical Systems Center
AT&T	American Telephone & Telegraph Company
ATF	advanced tactical fighter
BMAC	Boeing Military Airplane Company
CAD	computer aided design
CATAX	categorical exclusion
CBS	Columbia Broadcasting System News
CDR	critical design review
CEO	chief executive officer
CEQ	Council on Environmental Quality
CFC	chlorofluorocarbon

CMPS	corporate management policy statement
COEA	cost and operational effectiveness analysis
CPC	Charter Part Council
DAB	Defense Acquisition Board
Dem/Val	demonstration-validation
DFE	design for environment
DFEIS	design for environment information system
DID	data item description
DK	do not know
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDM	Department of Defense Manual
DUSD(ES)	Deputy Under Secretary of Defense for Environmental Security
EA	environmental assessment
EA	Environmental Assurance
EHMS	Environmental and Hazardous Materials Services
EIA	environmental impact analysis
EIS	environmental impact statement
EMD	engineering and manufacturing development
EPA	Environmental Protection Agency
EPACS	engine product and configuration support
EPS	engineering performance specification
ERM	Environmental Resource Management
ETR	engineering task request
FONSI	finding of no significant impact
FY	fiscal year

GAL	Gallup
GAO	General Accounting Office
GD	General Dynamics Corporation
GD-FT	General Dynamics, Fort Worth Division
GESP	Government Engines and Space Propulsion
GOCO	government-owned, contractor-operated
GOP	general operations procedure
H_a	alternative hypothesis
H_0	null hypothesis
HM	hazardous material
HMDB	hazardous material data base
HMMP	hazardous material management plan
HMMPO	Hazardous Materials Management Program Office
HMP	Hazardous Materials Program
HMPP	hazardous materials program plan
HMPPP	Hazardous Materials Pollution Prevention Program
HMRB	Hazardous Material Review Board
HNRP	human and natural resource protection
HQ USAF	Headquarters United States Air Force
IG	Inspector General
IPD	Integrated Product Development
IPT	integrated product team
IRAD	internal research and development
IVD	ion vapor deposition
k	constant
LADC	Lockheed Advanced Development Company
LASC	Lockheed Aeronautical Systems Company

LASR	logistic support analysis record
LCA	life cycle analysis
LFWC	Lockheed Fort Worth Company
LOB	lines of business
LSA	logistics support analysis
M&P	materials & processes
MDA-E	McDonnell Douglas Aerospace - East
MDAP	major defense acquisition program
MDC	McDonnell Douglas Corporation
MHAR	material hazardous action record
MIL-STD	military standard
MSDS	material safety data sheet
$\mathbf{n_1}$	number of subjects in group 1
$\mathbf{n_2}$	number of subjects in group 2
NA	not applicable
NAS	National Aerospace Standard
NCMS	National Center for Manufacturing Sciences
NEPA	National Environmental Policy Act
ODC	Ozone Depleting Chemicals
OSHA	Occupational Safety and Health Administration
OSHE	Occupational Safety, Health, and Environment
OTA	Office of Technology Assessment
P&W	Pratt & Whitney
PDR	preliminary design review
PEA	programmatic environmental assessment
PEIS	programmatic environmental impact statement
PIDS	prime item development specification

POP	process operation procedure
PPA	pollution prevention analysis
PPC	Pollution Prevention Committee
PWA	Pratt & Whitney specification
RA	risk assessment
RFP	request for proposal
ROD	record of decision
SA-ALC	San Antonio Air Logistics Center
SIP	state implementation plan
SOW	statement of work
SP	standard practice
SPO	system program office
SPOP	standard process operating procedure
TCA	1,1,1 trichloroethane
TCAB	Texas Air Control Board
TQM	total quality management
TRC	Technical Review Committee
TRI	Toxic Release Inventory
TRIS	Toxic Chemical Release Inventory System
US	United States
USA	USA Today
USAF	United States Air Force
UTC	United Technologies Corporation
VOC	volatile organic compound
WBS	work breakdown structure
WEC	Westinghouse Electric Corporation
WSHMAR	weapon system hazardous materials analysis report

CHAPTER I

INTRODUCTION

1.1 Overview

The Department of Defense (DoD) disposed of over 200 million pounds of hazardous waste in 1990[1]-- more than the top five industrial producers combined![2] Of the approximately 1400 DoD installations, the forty-three maintenance and repair depots accounted for seventy percent of the total. That is a staggering amount of hazardous waste given that DoD is not engaged in manufacturing activities at these facilities. The good news is that this represents a forty percent reduction over the amounts reported in 1987, the first year uniform DoD-wide disposal reports were submitted.

The materials and processes used by most DoD installations are driven by the need to operate, maintain, and repair existing equipment. As of September 1991, the average age of the active Air Force's 6,184 aircraft was 17.3 years.[3] Of this total, more than one-third were over 25 years old. Experience has shown that the majority of current costs associated with these systems were "determined" long ago, by decisions made early in the

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[1]US Department of Defense, "Hazardous Materials Pollution Prevention Committee Meeting Minutes," 5 November 1991, Office of the Deputy Assistant Secretary of Defense (Environment), Washington D.C.

[2]Stephen C. Lynn, and Neil G. Sylvestre, Pollution Prevention and the Acquisition of Aircraft Weapon Systems, (McLean, VA: MITRE Corporation under contract to the U.S. Air Force Aeronautical Systems Division, June 1992), 1-1.

[3]Tamar A. Mehuron, ed., "The US Air Force in Facts and Figures," Air Force Magazine, May 1992, 34.

system life cycle,[4] prior to the end of concept development. Given the long term cost and environmental impacts of decisions made early in a system's life cycle, designing and building "greener" systems is of critical long-term importance to the Air Force given the relatively long service lives of its systems.

DoD recognized the need to incorporate pollution prevention practices into system acquisition programs and issued DoD Directive (DoDD) 4210.15, Hazardous Material Pollution Prevention in 1989. The policy requires that hazardous materials be selected, used, and managed over their life cycle so that the DoD incurs the lowest cost required to protect human health and the environment.

Even though this policy was established in 1989, the acquisition community did little initially to implement it. They viewed the policy as an attempt by "outsiders," a functional staff not directly involved in acquisition, to inappropriately gain some control over the acquisition process. The policy was not taken seriously until it was incorporated into DoD Instruction (DoDI) 5000.2, Defense Acquisition Management Policies and Procedures, in 1991. Since 1991, the service components, product centers, and individual acquisition program managers have discovered that the current policy is difficult to implement.

The policy has not been effective in that it narrowly targets hazardous material selection during design, does not address the specific information to be evaluated at each milestone in the decision-making process, and does not clearly specify an appropriate decision framework.

As a result of these deficiencies, neither the Air Force nor the Department of Defense (DoD) has instituted a comprehensive pollution prevention program that can be applied to system acquisition programs. This research is intended to assist Air Force and

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[4]Wolter J. Fabrycky and Benjamin S. Blanchard, Life-Cycle Cost and Economic Analysis. (Englewood Cliffs, NJ: Prentice Hall, 1991), 12-13.

DoD decision-makers by clarifying policy, recommending a consistent decision framework, developing procedures for establishing program specific objectives, and demonstrating how environmental impact documentation can be used to provide relevant decision information at program decision milestones.

1.2 Outline

Chapter 2, Background, reviews and summarizes the literature in four key areas: the weapon system acquisition process, pollution prevention, alternative environmental management philosophies, and policy implementation.

Chapter 3 describes a pollution prevention implementation framework that establishes a set of criteria for evaluating and understanding what is needed to ensure that a system of pollution prevention analysis is established that can both meet the Air Force's goals and improve over time.

Chapter 4 details the research design and includes a statement of the problem, the three research questions of interest, the units of analysis, and the analysis methods.

Chapters 5, 6, and 7 present the results of the research with one chapter devoted to each research question. Chapter 8 summarizes the results of the research.

Appendix A covers the Air Force's pollution prevention values. Appendices B, C, D, and E contain case studies of pollution prevention in the aerospace industry. Appendix F includes information on the results of a questionnaire that was used examine attitudes toward environmental issues as part of the case studies. Finally, Appendix G contains the interview plan used to some of collect data for the case studies.

CHAPTER II

BACKGROUND

2.1 The Weapon System Acquisition Process

2.1.1 Systems Acquisition Management

The goal of the DoD's system acquisition policy and management processes is to provide the quality products needed by the Nation's armed forces in a way that effectively translates operational needs into stable, affordable acquisition programs.[1] This requires developing, building, fielding, operating, and ultimately disposing of systems that meet both performance and life cycle cost requirements. The process for doing this includes systematically translating an initial broad mission needs statement into specific performance requirements, which are then used to design the system.

The term acquisition is used in the context of developing and producing "big" defense systems. Procurement, on the other hand, will be used to describe the purchase of "little" things.

Acquisition policy is governed by DoD Directive (DoDD) 5000.1, Defense Acquisition. Several management concepts from this directive are important to understanding the implementation issues associated with pollution prevention. First, the directive requires short, clear lines of authority and accountability for all acquisition programs. The chain normally runs from a service acquisition executive, to a program

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[1]US Department of Defense, Department of Defense Directive (DoDD) 5000.1, Defense Acquisition, (Washington D.C.: US Department of Defense, 23 February 1991), 2-12 to 2-13.

executive officer, to the program manager. Within this structure, boards, councils, committees, and staffs are to facilitate decision making by providing advice to those responsible for managing programs. Those not in the direct chain of authority have no formal authority to issue program direction or to impede the progress of programs through the acquisition process. Thus, the promulgation of DoDD 4210.15 was not viewed as a binding requirement on acquisition programs. Pollution prevention only became binding when it was incorporated into 5000 series directives that govern system acquisition.

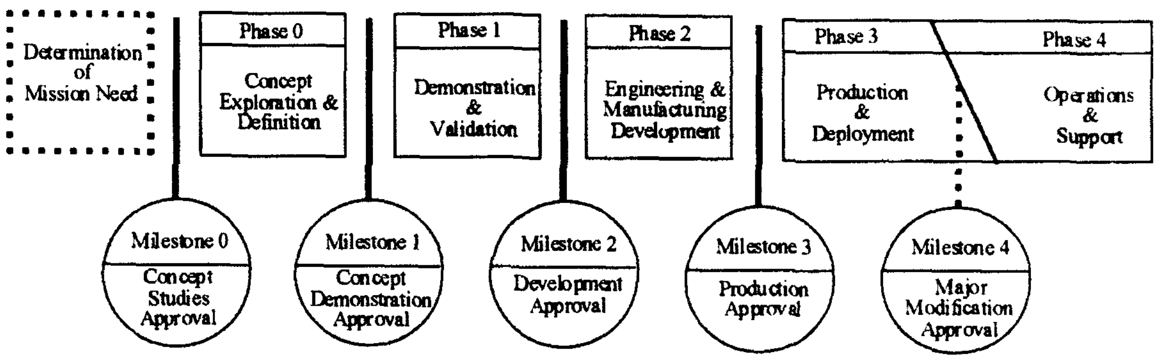

Figure 2.1. DoD Acquisition Process

Figure 2.1[2] shows the current DoD system acquisition process. This management structure follows a life cycle concept closely, except that it lacks a disposal phase--disposal being a Defense Reutilization and Marketing Service responsibility. Disposal costs and impacts are not ignored in acquisition; however, since they are addressed in programmatic cost analyses and environmental assessments.

[2]US Department of Defense, Department of Defense Instruction (DoDI) 5000.2, Defense Acquisition Management Policies and Procedures, (Washington D.C.: US Department of Defense, 23 February 1991), 2-1.

2.1.2 Historical Context

To produce new systems that are more environmentally friendly, pollution prevention practices must be incorporated into the DoD systems acquisition process. This is a difficult task since the acquisition process itself is constantly being revised in response to alleged and actual shortcomings. Many believe that the weapons-acquisition process has been in deep trouble for years. Thus, one must understand the current process and some of its ailments, if pollution prevention is to be successfully implemented.

In the first chapter of his book, Gregory outlines some of the problems:

> One of the basic causes of the acquisition system's illness is the prescriptions of a regiment of doctors who set out to cure what was merely a nasty cold. Only the experience of a relative handful of veteran military and civil servants, along with a tested industrial cadre, has been able to keep it functioning as well as it does. They are fighting an overwhelming burden of paperwork, bureaucratic layers, and second-guessing, . . . In this mire of paperwork and regulation . . . the program manager has been submerged and the time it takes to develop and field new hardware has stretched out grotesquely.
>
> Eclipsed program managers are not the root cause of the acquisition mess, but rather a symptom and symbol of the fact that the government does not trust its own people or those in industry to carry out the job. The mischief that this lack of confidence has bred is awesome. . . .
>
> . . . Generations of over management by higher and higher levels of government--that is, micromanagement--is a primary cause of the defense procurement mess. Another basic cause is over regulation and over specification (often in response to past problems), which have created massive paperwork requirements in military contracting, costing the taxpayer from 25 percent to more than half of the price of producing weapons themselves. . . .
>
> . . . Adversarial relationships further poison the process. . . . All through the layers of the Pentagon, people are supervising. Do they coordinate with each other? Contractors, who are at the end of the chain, doubt it. . . . Over staffing, which stifles effective program management, contributes to the problem.[3]

These problems are not new. Fox provides a retrospective of the major studies of the acquisition process from Peck and Scherer in 1962 to the Packard Commission in 1986. He concludes,

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[3]William H. Gregory, The Defense Procurement Mess, (Lexington, MA: Lexington Books, 1989), 2-4.

> After twenty-seven years of initiatives to improve the acquisition process, it is increasingly evident that any changes must include careful and consistent implementation if they are to succeed. . . . In considering improvements to the acquisition process, one may do well to remember that there is no sovereign power in Washington; instead, there are many independent powers. . . .Acquisition reforms up to 1987 have tended to attack the symptoms of cost increases, not their causes, and at best have been only partially implemented. They have left the basic negative incentives for government and industry personnel largely undisturbed.[4]

The history of the Carlucci initiatives provides a good example of the implementation failures of past acquisition reform efforts. In 1981, Deputy Secretary of Defense Frank Carlucci issued a set of thirty-two reforms. He stated, "The primary objectives are to reduce costs and shorten the acquisition time--streamline the process."[5] This was to be accomplished mainly by reducing over-regulation. In 1986, five years after the initiatives were issued, the General Accounting Office (GAO) studied the impact of the initiatives and concluded that the initiatives had made little or no difference because the DoD had not carried through with its action plans on most of the initiatives.[6] This history of failure to implement key policy changes that are at the core of the every acquisition manager's responsibilities is clearly an ominous sign for implementation of pollution prevention.

Fox investigated why it is so hard to control acquisition costs. One of the big impediments identified was socioeconomic programs, government controls, and red tape. Fox looked at past attempts to integrate non-defense societal goals into the acquisition process and found,

> One of the most common complaints from defense contractors has been that doing business with the government is difficult, time consuming, and costly. . . . In

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[4]J. Ronald Fox, The Defense Management Challenge: Weapons Acquisition, (Boston: Harvard Business School Press, 1988), 51.

[5]George Sammet Jr. and David E. Green, Defense Acqui i ion Management, (Boca Raton, FL: Florida Atlantic University, 1990), 15

[6]US General Accounting Office, "DoD's Defense Acquisition Improvement Program: A Status Report," July 1986, 12-14, GAO/NSIAD-86-148.

> addition, the government may seek to use the procurement process to help accomplish its socioeconomic objectives: maintaining employee health and safety, protecting the environment, supporting small business. . . .[7]

The organizational response to this is to try to isolate acquisition managers from "outside" pressures to the maximum degree possible. Peck and Scherer studied whether political and socioeconomic objectives play a significant part in the source selection of contractors and they conclude that these considerations, ". . . . have not played a really major role in the choice of contractors."[8] They attribute the overall lack of significance during source selection to the view that they largely cancel each other out. Their study did not determine if the socioeconomic objectives were achieved.

Fox[9] illustrates the high level of complexity of weapon systems in relation to non-defense systems by looking at the part counts and reliability of several defense systems. The Lockheed C-141 has 250,000 parts and required 20,000 engineering drawings to manufacture. By comparison, an automobile of the same time (1972) had approximately 3,000 parts. This is only 1/750 as many as the C-141. The F-15 fighter aircraft has 585,000 parts.[10] The Army's Nike-Hercules system consists of more than one million parts. The same 1972 automobile driven continuously for 1,000 miles at 50 miles per hour, has an average mean time between failure of 90 hours. Fighter aircraft in the early 1970s averaged 150 hours--1.67 times the automobile's rate. Maintaining these systems is also a complex process. There are 98,916 pages of technical manuals and supply manuals for the Hercules missile system, 55,927 pages for the Hawk, and 45,063 pages for the Pershing. The F-15 requires fifty-three person-hours of maintenance for every hour it flies.

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[7] Fox, The Defense Management Challenge: Weapons Acquisition, 39.

[8] Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis, (Boston: Harvard University, 1962), 381.

[9] J. Ronald Fox, Arming America: How the U.S. Buys Weapons, (Cambridge MA: Harvard University Press, 1974), 15-24.

[10] Fox, The Defense Management Challenge: Weapons Acquisition, 10.

In order to deal with the issues that this level of complexity brings, Secretary of Defense McNamara issued acquisition directives on a host of issues throughout the 1960s including planning procedures for integrated logistics support, quality assurance, value engineering, technical data management, configuration management, a work breakdown structure (WBS) format for program management, and a host of others According to Fox, the results have been disappointing because the level of training for DoD acquisition managers fell far short of the level of sophistication required to implement the new policies and directives.[11] Will the system respond better to the training requirements needed to implement pollution prevention?

McNaugher categorizes the problems associated with the acquisition process into three dimensions: technical, military, and political, where each dimension has special requirements that are often in tension with one another.[12] He then goes on to state, "The problem starts at the bottom of the acquisition process, in an elaborate requirements process that establishes cost and performance goals, as well as detailed technical specifications."[13] In developing the requirements for a new system, political forces create a powerful unit-veto system where many people can say no to a project, but few can approve it. In many cases, the threat of veto comes from individuals who attach important goals to a new project by embedding requirements in detailed specifications that cannot be easily traded away during development. In this view, pollution prevention would be categorized as just the type of second or third level issue (as compared to cost. schedule, and performance) that McNaugher cites as one of the root causes of the procurement mess. He concludes his chapter on Perverse Priorities stating,

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[11]Fox, Arming America: How the U.S. Buys Weapons, 44.

[12]Thomas L. McNaugher, New Weapons, Old Politics: America's Military Procurement Muddle, (Washington D.C.: The Brookings Institute, 1989), 1.

[13]Ibid., 124.

Starting with the simple truth that soldiers, policymakers, technicians, and politicians all have a right to some say over weapons acquisition, the nation has arrived at a process in which these groups fight for control continuously over the course of development. And because everyone has partial control over part of the process, no one has control over all of it. Weapons and forces are political outcomes, just like policy choices in other areas of government activity.[14]

McNaugher sees the concept of short direct lines of authority in DoD as an illusion. If one accepts that outcomes are based on a political process, issuing a pollution prevention directive is unlikely to have much impact without a consensus that the policy is appropriate by the key players.

One of the newest reform efforts by the Carnegie Commission on Science, Technology, and Government tries to forge just such a consensus. The commission, which included many individuals with high-level national security experience,[15] suggests a total overhaul of the current system. "What is required is a complete break with the present system, and the creation of a new system based on the best of the acquisition processes used by large corporations when they undertake major development projects. . ."[16] The commission justifies this recommendation saying,

The critical ingredient of adaptation to commercial practices is conversion from a regulation-based system to a market-based system. Numerous studies have made it clear that the problems with the defense acquisition system are rooted deeply in the regulation-based system of procurement, with its insidious system of "allowable overhead."[17]

The nature of the defense market, as it applies to large defense dominated companies, has indeed been studied in great detail. Fox, quoting Peck and Scherer's work in exploring the weapons acquisition market, found that it was unique in market terms:

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[14]Ibid., 148.

[15]The chairman, William J. Perry, has since become Secretary of Defense in the Clinton administration.

[16]A Radical Reform of the Defense Acquisition System, William J. Perry, Chairman, (New York: Carnegie Commission on Science, Technology, and Government; Task Force on National Security, 1 December 1992), 1.

[17]Ibid., 3.

In the defense industry there is little that resembles the free market. In 1962 Peck and Scherer stated, "A market system does not now exist in the weapons acquisition process. We can state the proposition more strongly. A market system in its entirety can never exist for the acquisition of weapons." In the 1970s the situation has not changed.[18]

Some of the differences between commercial markets and the weapons acquisition market are summarized in Figure 2.2.[19]

Industrial Market	Defense Market
The seller initiates new product innovations, based on analysis of potential markets. He has no certain knowledge of a product's salability	The buyer establishes the requirements for a product. The producer then begins development and production
The buyer has a wide range of choice between products in the same category that have real or advertised differences	Relatively few products are produced simultaneously for the same mission. Although the buyer sometimes has the option to choose among prototypes, the time and cost of producing new systems once production has begun discourages replacement
Price is a dominant factor in a buyer's choice because adequate substitutes for a product are often available	Price is only one of the factors that govern a customer's choice. It may be far less important than quality, availability, or the technology required to realize a specific program objective
The market tends to be impersonal. Buyers and sellers act independently	The market is highly personal. The buyer has constant contact with the seller's organization
The producer finances the development-production effort	The buyer bears most of the development cost and may provide equipment and facilities for the use of the producer
The market usually contains several, or many, customers	The market is essentially one-customer (monopsonistic)
Prices are primarily determined by competition	Price is determined by an evaluation of anticipated and actual costs
Demand is either relatively constant or tends to be a function of disposable income	Demand is a function of the technology available, or of estimates of a potential enemy's technological resources
The basic design of the product changes slowly and requirements for a given model are relatively stable	The product may be technologically obsolete before production is completed

Figure 2.2. Defense Market Conditions

[18]Fox, Arming America: How the U.S. Buys Weapons, 26.

[19]Lt. Col. David I. Cleland and 1Lt. William R. King, "The Defense Market System," Defense Industry Bulletin (January 1968): 8, quoted in Fox, 39.

Peck and Scherer noted that while the prime contractors do not operate under market conditions, many of the components used in a system do have market prices since they come from subcontractors that do operate under market conditions. They cite generators, electron tubes, and air conditioning units as examples.[20] While the technologies have changed, a prime contractor still relies on thousands of subcontractors to supply parts, components, sub-assemblies and sub-systems. Peck and Scherer concluded that the choice of subcontractors is seldom made simply in terms of price.[21] Rather, time, quality, and cost considerations are all important.

Current DoD policy calls for using commercial parts and specifications to the maximum extent possible as a means of reducing cost. The Carnegie Commission obviously believes meaningful change is impossible without a major overhaul. This raises several important questions for pollution prevention. First, what are the current pollution prevention practices in the aerospace industry and second, should the Air Force use commercial development practices to achieve its pollution prevention objectives?

2.2 Pollution Prevention

2.2.1 What is Pollution Prevention?

This question has been widely debated. EPA policy states,

> Pollution prevention means 'source reduction,' as defined under the Pollution Prevention Act, and other practices that reduce or eliminate the creation of pollutants . . . Under the Pollution Prevention Act, recycling, energy recovery, treatment, and disposal are not included within the definition of pollution prevention.[22]

[20]Peck and Scherer, 57.

[21]Ibid., 387.

[22]F. Henry Habicht II, Deputy Administrator, US Environmental Protection Agency, memorandum to All EPA Personnel, "EPA Definition of Pollution Prevention," 28 May 1992.

EPA's definition refers to the waste management hierarchy which orders waste management options according to their possible environmental consequences. The hierarchy consists of four options: 1) source reduction, 2) recycling, 3) treatment, and 4) disposal. In principle, options one and two offer more protection than those at the end [23]

Understanding the variety of alternatives each option in the hierarchy represents is important for understanding the management options included or excluded by a program or management system. For example, source reduction generally includes product changes, material changes, technology changes, and good operating practices.[24] Product change refers to reducing waste by changing the product through substitution, conservation, or changes in product composition. Material changes accomplish prevention by reducing or eliminating the hazardous materials that enter a process and include material purification and material substitution. Technology changes include changes in production processes; equipment, layout, or piping changes; use of automation; and changes in process operating conditions. Good operating practices include material handling and inventory practices, loss prevention, waste segregation, cost accounting practices, production scheduling, and management and personnel practices. Each of the other terms is, likewise, a shorthand categorization of a number of potential release reduction management strategies.

A review of the pollution prevention literature by Freeman et al[25] highlighted the debate over the definition of pollution prevention. Foecke sees the concept of preventing

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[23]Katy Wolf, "Source Reduction and the Waste Management Hierarchy," J. Air & Waste Management Association 38, no. 5 (May 1988): 681.

[24]US Environmental Protection Agency, Risk Reduction Engineering Laboratory, Waste Minimization Opportunity Assessment Manual, (Cincinnati, OH: US Environmental Protection Agency, July 1988), 15-17, EPA/625/7-88/003.

[25]Harry Freeman, Teresa Harten, Johnny Springer, Paul Randall et al., "Industrial Pollution Prevention: A Critical Review," J. Air & Waste Management Association 42, no. 5 (May 1992): 618-656.

cross-media transfers of pollution as the heart of the concept.[26] Klee characterizes pollution prevention as, "A means, not an end," where, "the end or goal is improved environmental quality." In support of this view, he offers a results-oriented definition, "Preventing releases into the environment."[27]

Freeman includes comments by Ross stating that pollution prevention, or whatever term is selected, should, "Reflect a results-oriented, rather than a process-oriented approach." Ross is also quoted offering a definition of pollution prevention that includes,

> Activities that have the potential to transform industry from material intensive, high throughput processes to systems that use fuel and raw materials highly efficiently, rely on inputs with low environmental costs, generate little or no waste, recycle residuals, and release only benign effluents.[28]

Much of the concern over the definition of pollution prevention springs from a concern that a narrow definition does not provide a guiding philosophy for environmental management that the early users of the term envisioned. Unfortunately, the meaning of pollution prevention has been legislated by Congress and it is now a regulatory term, defined by EPA, that encompasses a narrow set of "preferred" methods. Klee summarizes the situation with an equation:

Limited Definition = Limited Results[29]

Why is a broader vision needed? Wolf summarizes the problem in her discussion of the use of the waste management hierarchy:

> Each waste management problem requires a system approach. In some specific cases, it may be "better" to recycle or treat a hazardous substance than it is to adopt a source reduction option. The hierarchy is therefore useful for organizing our approach to waste management. It should not, however, be followed literally

[26]Terry Foecke, "Industrial Pollution Prevention: Critical Review Discussion Papers." J. Air & Waste Management Association 42, no. 9 (September 1992): 1163.

[27]Howard J. Klee, "Industrial Pollution Prevention: Critical Review Discussion Papers." J. Air & Waste Management Association 42, no. 9 (September 1992): 1164.

[28]Freeman et al, 620.

[29]Klee, 1164.

and rigidly without taking into account the host of characteristics surrounding each individual waste management case.[30]

Levin reaches a similar conclusion in his discussion of pollution prevention incentives and irrationalities stating, "It is by no means true that all reductions in waste are equally good, that all reductions at the beginning rather than the end of a production cycle are preferable, or that reductions to zero are a goal to be desired regardless of risk, cost, or the benefits secured."[31]

Problems concerning program definitions and scope are not trivial for the Air Force or DoD. One need only look at the Aerospace Industries Association's (AIA) July 14, 1992, proposal for a new military standard for implementing DoD's Hazardous Materials Pollution Prevention Program (HMPPP).[32] While the AIA's proposal has many positive points, it takes a very restrictive approach that would exempt all but the biggest acquisition programs from the HMPPP requirements. The AIA recommends that all contracts with values less than $100 million be exempt. Developmental contracts with values for research and development less than $300 million in fiscal year 1990 constant dollars or eventual total expenditures for procurement less than $1 billion would only be required to identify and report the hazardous materials the contractor intended to use. A "full" hazardous materials pollution prevention program would only be accomplished on developmental contracts bigger than these limits. If the industry proposal were to be accepted, DoD would clearly end up with limited results.

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[30]Wolf, 685.

[31]Michal H. Levin, "Implementing Pollution Prevention: Incentives and Irrationalities," J. Air & Waste Management Association 40, no. 9 (September 1990): 1230.

[32]LeRoy J. Haugh, Vice President, Procurement and Finance, Aerospace Industries Association, to Ms. Maureen Sullivan, US Department of Defense, "Draft Military Standard for Hazardous Material Management" 14 July 1992, Washington D.C.

2.2.2 Pollution Prevention in Systems Acquisition

DODI 5000.2 implements the hazardous materials pollution prevention program (HMPPP) in acquisition programs. The focus of the HMPPP is on hazardous materials evaluation and substitution--making it a strong a source reduction program. The key provisions of the HMPPP require 1) evaluation of the environmental, safety, and occupational health impacts associated with hazardous materials; 2) management of the selection, use, and disposal of hazardous materials over the system life cycle so that the DoD incurs the lowest cost required to protect human health and the environment; and 3) procedures for identifying, tracking, storing, handling, and disposing of hazardous materials that cannot be avoided.[33] Since the HMPPP is focused on material substitution, it does not address other forms of source reduction.[34]

2.2.3 Pollution Prevention and Concurrent Engineering

The concurrent engineering concept of design and development, as used in DoD, includes using a life cycle approach. DoD has used its version of concurrent engineering (called systems engineering) for many years to deal with non-environmental system

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[33]Department of Defense Directive (DoDD) 5000.2, Section I.3.c. states,

The environmental, safety, and occupational health impacts associated with the selection and use of hazardous materials will be carefully evaluated during the acquisition of systems. This includes the impacts associated with manufacturing, operation, maintenance, and disposal of the system.

(1) The selection, use, and disposal of hazardous materials in the systems acquisition process shall be managed over the system life cycle so that the DoD incurs the lowest cost required to protect human health and the environment. Guidance is contained in DoD Directive 4210.15, "Hazardous Material Pollution Prevention."

(a) The preferred method of doing this is to avoid or reduce the use of hazardous material.

(b) This also includes designing explosives systems with attributes that will assist Explosive Ordnance Disposal personnel in rendering them safe.

(2) Life cycle cost estimates must include the cost of acquiring, handling, using, and disposing of any hazardous or potentially hazardous materials.

(3) Where use of hazardous material may not reasonably be avoided, procedures for identifying, tracking, storing, handling, and disposing of such materials and equipment will be developed and implemented as outlined in DoDD 4210.15 and DoDI 6050.5, "Hazardous Communications Program.

[34]See Figure 3.3 for other types of source reduction.

characteristics such as reliability, maintainability, survivability, producibility, supportability, system safety, health hazards, and human factors. Fabrycky and Blanchard define concurrent or simultaneous engineering as, "An integrated approach that depends on life-cycle thinking."[35] DoD has traditionally had a strong concern for life cycle issues and solutions since it determines product requirements, funds development and manufacturing, and then owns, operates, and maintains its systems. This is unlike the situation most often encountered in the private sector, where the consumer or user is usually not involved in a product's design.

Concurrent engineering is also concerned with parallel development of the product and the related processes to shorten the development cycle by ensuring that steps that can be done in parallel are not done in sequence thereby reducing development time and cost.

DoD Instruction (DoDI) 5000.2, Defense Acquisition Management Policies and Procedures, describes systems engineering as a comprehensive, iterative, technical-management approach for translating an operation need into a configured system through a systematic, concurrent approach to integrated design that integrates the technical inputs into a coordinated effort while meeting established program cost, schedule, and performance objectives and managing technical risks.[36]

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[35]Wolter J. Fabrycky and Benjamin S. Blanchard, Life-Cycle Cost and Economic Analysis (Englewood Cliffs, NJ: Prentice Hall, 1991), 4.

[36]DoD Directive 5000.2, Section A.2.a.: "Systems engineering shall be applied throughout the system life cycle as a comprehensive, iterative technical management process to:

1. Translate an operation need into a configured system meeting that need through a systematic. concurrent approach to integrated design of the system and its related manufacturing, test, and support processes;

2. Integrate the technical inputs of the entire development community and all technical disciplines (including the concurrent engineering or manufacturing, logistics, and test) into a coordinated effort that meets established program cost, schedule, and performance objectives;

3. Ensure the compatibility of all functional and physical interfaces (internal and external) and ensure that system definition and design reflect the requirements of all system elements: hardware, software, facilities, people, and data; and,

4. Characterize technical risks, develop risk abatement approaches, and reduce technical risk through early test and demonstration of system elements."

Since concurrent engineering is a team approach, design decisions can be made in full light of life cycle requirements, including environmental requirements, by including all the technical specialists who have a stake in the issue. Thus, system design can proceed in parallel with manufacturing process design, operational planning, training system development, logistics support planning, facility planning, etc. The goal is to properly balance competing requirements as the design proceeds and not have to go back and reconsider because all the requirements were not included when decisions were being made. The need for speed and efficiency must be balanced with the need to make sound, well-reasoned design choices. The reality is that concurrent engineering, like all design processes, is both iterative and cyclic.[37] Concurrent engineering is successful, then, if the length and number of iterations and cycles can be minimized.

Technical risk and uncertainty should be lower in a traditional sequential development process than in a concurrent process. In a sequential process, technical issues at each step can be resolved before moving forward to the next step. Thus, reduced technical risk is one of the main advantages of a lengthy development process that trades time and cost for reduced risk. The result of reducing technical risks is an increased probability of meeting performance requirements. In a concurrent process, technical risks are a major roadblock to speed of development. If wrong choices are made, much effort is wasted and must be redone in the parallel processes. Life cycle issues serve to further complicate the analysis and slow the process.

A problem in addressing life cycle issues is that those responsible for the issues may be tempted to sub-optimize instead of working toward the best overall design. Chase warns that past efforts to incorporate life cycle issues often results in the creation of special interest groups or "cults." Chase sees the creation of cults that are devoted to

[37]Mark Oakley, Managing Product Design, (New York: John Wiley, 1984), 95.

improving and controlling the quality of a single design characteristic as destructive to the teamwork needed in systems engineering:

> . . .Government contracting for system development programs supports various . . . activities, such as reliability, maintainability, safety, and human and value engineering, by providing separate funding for each. The resultant special interest groups, each with redundant system engineering objectives, have become embedded in a bureaucratic organization. Consequently, they tend to become highly resistant to any mutually supporting teamwork approaches. . .[38]

Chase sees strong central product-oriented system design and engineering management as the solution to the cults where:

> Design and trade-off studies constitute the mainstream of the system design effort. When this effort is properly supported by functional requirements and system performance-effectiveness analyses, it is possible to conduct trade-off studies which will include consideration of operational use objectives as well as technological ones in alternative system design approaches. In carrying out this system-oriented design approach, all of the so-called "ilities" which have been nurtured by the "cults" will be appropriately applied as integral factors in trade-off studies. These include reliability, maintainability, safety engineering, human engineering, and value engineering. . .[39]

Achieving this integration between system performance requirements and functional requirements is an important aspect of concurrent engineering. It should be a primary goal of pollution prevention implementation efforts as well.

In addition to system performance and function requirements, trade-off studies are also concerned with controlling technical risks. The goal in the early program phases is to search for a match between an acceptable set of system requirements (both performance and functional), achievable technologies, and available resources. A concurrent engineering approach in system acquisition should attempt to balance the need for speed with the need for considering life cycle issues. Environmental technical uncertainty should

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[38]Wilton P. Chase, Management of System Engineering, (New York: John Wiley, 1974), 49.

[39]Ibid., 41.

be managed along with other program technical risks. Achieving this would be a major change from current practice.

A key element in implementing pollution prevention in a concurrent engineering approach is the type of contract. Systems that employ concurrent engineering, such as the F-22, are being developed with cost type contracts where the government assumes total cost risk and responsibility. Nevertheless, the program manager's key task is to balance cost, schedule, and performance and keep the program moving forward. This requires clear goals, the ability to make balancing decisions, and clear guidance to the contractor-government management team. The concurrent engineering team concept works because the government and contractor have a greatly reduced needed to act in adversarial ways. This allows the program to have a broader set of performance and technical requirement and provides flexibility to make performance-cost-schedule trades during design--helping to reduce risks. In a fixed price environment, requirements must be well defined before the contract is signed. Once the contract is signed, the contractor assumes the cost risk and the government has little incentive to help manage technical risks.

Does this process work? The approach requires an empowered program manager, clear direction from above, and noninterference from outside. Meeting these requirements in DoD has proven to be difficult, but DoD's strong commitment to a life cycle approach and the systems engineering process provides a strong foundation on which to build a comprehensive pollution prevention program within its acquisition programs.

2.2.4 The Air Force Pollution Prevention Program

The objective of the Air Force Pollution Prevention Program (AFPPP) is to prevent future pollution by reducing use of hazardous materials and releases of pollutants into the environment to as near zero as feasible.[40] In addition to this overall objective, the

[40]Donald B. Rice, Secretary of the Air Force, and Merrill A. McPeek, General, Chief of Staff, joint memorandum to All Major Commanders, "Air Force Pollution Prevention Program," 7 January 1993.

program also has six strategic objectives. Objective 1, which addresses the acquisition of new systems, is shown in Table 2.1 along with its sub-objectives.

<u>OBJECTIVE 1</u>: Reduce the use of hazardous materials in all phases of new weapon systems from concept through production, deployment and ultimate disposal -- find alternative materials and processes, and measure their life cycle costs. <u>SUB-OBJECTIVES</u>: By the end of 1994, institutionalize pollution prevention including hazardous materials minimization and management into the system acquisition process (concept, design, development, test and evaluation, modification, operation, maintenance, and ultimate disposal) through the use of policies, procedures, training, contract provisions, and Federal Acquisition Regulations changes. Develop and incorporate procedures into system development milestone criteria that require: - identification of hazardous materials, evaluation of environmentally acceptable alternatives, and selection of alternatives where indicated by life cycle analysis - identification of the remaining hazardous materials and the alternatives considered and reasons for their rejection - estimates of the quantities of each hazardous material needed through the lifetime of the system, based on the most current concept of operations Replace hazardous material requirements in new system TOs, MILSPECs, and MILSTDs with environmentally acceptable alternatives. Where none exists, prioritize the uses, select the ones with the highest potential improvement, and conduct a Science and Technology or Manufacturing Technology effort to develop alternatives. Identify material and process substitution needs critical to achieving pollution prevention objectives for integration into the Science and Technology Program. Obtain the resources required to accomplish the objectives.

Table 2.1. Air Force Pollution Prevention Program Action Plan
System Acquisition Objectives

2.3 Beyond Pollution Prevention

2.3.1 <u>Product Design Strategies</u>

Fabrycky and Blanchard state that the vast majority of product's life cycle cost is determined very early in the development process: often 66% by the end of concept design

and 80% by the end of detail design.[41] Thus, early decisions on requirements and basic design decisions are critical. Eekles points out that the same is true for environmental effects, they are, "largely fixed at design."[42] Freeman et al. believe that existing design approaches fall,

> . . . on a continuum that begins with very limited and specific, such as design for recyclability, disposability, or remanufacturability, and ends with a comprehensive, life cycle design strategy. . .
>
> In contrast to single or limited dimensional environmental design strategy, life cycle design assumes no single approach to be appropriate for all projects. Instead, selection of the best strategy or combinations of strategies is based on satisfying life cycle design requirements. Effective strategies for life cycle design can only be developed after project objectives have been refined and characterized. The specification of design requirements is the most critical step in achieving risk and environmental impact reduction. . .
>
> . . . Key principles of life cycle design are:
>
> 1. Recognition of all activities involved in product and process design from extraction of raw materials to the ultimate fate of residuals.
> 2. Inclusion of environmental requirements at the earliest stages of product development.
> 3. Cross-disciplinary development teams.
> 4. Recognizing environmental impacts as a measure of quality.[43]

The need to set design requirements and objectives prior to selecting the best strategy for achieving risk and environmental impact reduction is an important point for implementing pollution prevention in acquisition programs. Philosophically, DoD's current approach includes three of Freeman's principles: the second, third, and to a limited degree, the fourth. The first principle is embodied in the philosophy of industrial ecology--a philosophy DoD has yet to fully embrace.

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[41]Fabrycky and Blanchard, 12-13.

[42]J. Eekles et al, "Design and Waste Prevention," Advisory Council for Research on Nature and Environment, Rijswiik, The Netherlands, February 1988, cited by Harry Freeman, Teresa Harten, Johnny Springer, Paul Randall et al., "Industrial Pollution Prevention: A Critical Review," J. Air & Waste Management Association 42, no. 5 (May 1992): 644.

[43]Freeman et al, 644.

2.3.2 Industrial Ecology

Industrial ecology provides a new perspective for thinking about the relationships between the environment, indeed, the biosphere and industrial sy-tems. Frosch defines industrial ecology as, "the network of all industrial processes as they may interact with each other and live off each other, not just in the economic sense but also in the sense of the direct use of each other's material and energy wastes and products."[44] Frosch believes that we need to think of wastes not only as outputs to be prevented by proper choice but also as part of the industrial process product stream that is to be designed. He illustrates the concept with an ecological analogy:

> In nature, an ecological system operates through a web of connections in which organisms live and consume each other's waste. The system has evolved so that the characteristic of communities of living organisms seems to be that nothing that contains available energy, or useful material will be lost. . . Ecologists talk of a food web: an interconnection of uses of both organisms and their wastes. In the industrial context, we may think of this as being the use of products and waste products. . .[45]

Lowe[46] describes industrial ecology as a framework for redesigning the industrial system to bring it into harmony with the global ecosystem by applying ecological principles. Lowe also discusses Life Cycle Analysis, Total Quality Management, Design for Environment, and other approaches to environmental management. He concludes that industrial ecology is, "a unifying framework and theoretical foundation--exactly what's needed to blend these scattered and incremental efforts into a coherent whole."[47]

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[44]Robert A. Frosch, "Industrial Ecology: A Philosophical Introduction," in Proceedings of the National Academy of Sciences (A colloquium on Industrial Ecology) Held in Washington D.C., 20 May 1991, (Washington D.C.: National Academy Press, February 1992), 800-803.

[45]Ibid., 800.

[46]Ernest A. Lowe, Discovering Industrial Ecology: An Overview and Strategies for Implementation, Discussion Draft, (Oakland, CA: Change Management Center, May 1992), 1.

[47]Ibid., 3.

2.3.3 Life Cycle Analysis (LCA)

"EPA's definition of LCA involves examining the environmental releases and impacts of a specific product by tracking its development from a raw material, through its production, and eventual disposal."[48] LCA takes a holistic approach to design by analyzing the entire life cycle of a product, process, or activity.

The findings of a workshop on LCA by the Society of Toxicology and Chemistry (SETAC) concluded that LCAs should be composed of three separate components: 1) a life-cycle inventory, 2) a life-cycle impact analysis, and 3) a life-cycle improvement analysis.[49] This result is not surprising in that it follows the logic of preparing an environmental impact statement closely. One of the greatest obstacles to widespread use of LCA is that data on many of the processes are not available.

2.3.4 Total Quality Management

Another way to look at the environmental impacts associated with a product is to view them as quality defects in a total quality management (TQM) program. Overby describes how Taguchi's design concepts for producing high quality products at low cost apply to environmental objectives. He explains that Taguchi's concept,

> . . . Divides quality into "off line" and "on line" quality control. Off line quality control is an intense engineering focus on building quality into the product, starting at the very beginning of product and process design. Among other things, he emphasizes the use of experimental design to create "robust" products and processes that are insensitive to the noise and perturbations of normal operations. On line quality control in Taguchi's terminology deals with controlling quality after the designs are finished. This is more like the traditional approach to quality

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[48]Harry Freeman, Teresa Harten, Johnny Springer, Paul Randall et al., "Industrial Pollution Prevention: A Critical Review," J. Air & Waste Management Association 42, no. 5 (May 1992): 641, citing Product Life Cycle Assessments: Inventory Guidelines and Principles, (Columbus, OH: Battelle, for US EPA, 1991).

[49]Society of Environmental Toxicology and Chemistry, in Workshop Report: A Technical Framework for Life-Cycle Assessments Held in Smugglers Notch, VT, 18 August 1990, eds. Fava, James A., Richard Denison, Bruce Jones, Mary Ann Curran, Bruce Vigon, Susan Selke, and James Barnum (Washington D.C.: Society of Environmental Toxicology and Chemistry, January 1991), 176.

> control. Pollution prevention by design is analogous to Taguchi's "off line" quality control -- quality by design. Pollution control, the traditional end-of-pipe treatment approach, is analogous to "on line" quality, the traditional quality control approach. In both cases, pollution prevention by design, and quality by design, the pollution and poor quality are not allowed to occur in the first place.[50]

Overby also provides some examples of how Taguchi's loss functions can be used. The key is Taguchi's concept of quality that he defines as the loss a product causes to society after being shipped. Using this idea, customer requirements for clean air, water, and land could be used to create quality loss functions. Functions might include minimizing the pollution from a process where the ideal value is zero or might include maximizing or attaining a set value for the recyclability, remanufacturability, or other desirable traits.

2.3.5 Design for Environment (DFE)

Glantschnig and Sekutowski describe DFE as, "A design philosophy and practice whose goal is to minimize the environmental impact of manufacture, use, and eventual disposal of products without compromising essential product functions, and without significantly affecting the life cycle cost of the product in a negative way."[51] DFE is implemented by applying the methods of concurrent engineering to solve some of the environmental problems. They describe AT&T's approach as a structured technical program that uses guidelines, checklists, and scoring systems to help improve environmental characteristics of a product or process. Finally, they note that, "The difference between life cycle analysis and DFE is that the former is a comprehensive, but not yet practical, green design approach, whereas the latter is a more limited program ready to be implemented now."[52]

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[50]Charles Overby, "Design for Environmental Elegance," Green Engineering: Designing Products for Environmental Compatibility, ed. D. Navin chandra : draft manuscript, October 1992), 9.

[51]Werner J. Glantschnig and Janine C. Sekutowski, "Design for Environment: Philosophy, Program, and Issues," Green Engineering: Designing Products for Environmental Compatibility. ed. D. Navin chandra : draft manuscript, October 1992), 2.

[52]Ibid., 5.

Allenby and Fullerton define DFE as an effort, "to implement industrial ecology principles into a systems analysis approach to environmental management," by integrating environmental considerations into product and process engineering design procedures.[53] The term environmental considerations is used with its broadest meaning, to include, social, cultural, economic, and political dimensions of environmental issues. Implementation of DFE centers on two tools. First, a generic set of procedures and practices that could be modified by individual firms to meet their needs and second, a DFE information system or DFEIS that would be designed to summarize the relevant environmental, health, and safety; social; economic; and regulatory data applicable to a specific design option.

Glantschnig and Sekutowski state that the DFE methodology for waste minimization and pollution prevention, "starts with compiling a projected waste stream inventory" as soon as a preliminary design is available, and a manufacturing process sequence can be mapped out.[54] Ideally, the inputs and outputs should be quantified and related to some product unit. Once the inventory is complete, opportunities for waste minimization through the modification of design or material specifications, and the selection of alternative manufacturing processes, can be investigated. They see the main tool for evaluating alternatives as a system that allows "effortless compilation of projected waste stream inventories."[55] The conceptual system consists of two data bases, a process data base containing information about energy consumption and the nature and quantity of waste streams generated by each unit process and an impact data that contains information about the ecological and toxicological impacts of the various materials and wastes.

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[53]Braden R. Allenby and Ann Fullerton, "Design for Environment - A New Strategy for Environmental Management," Pollution Prevention Review, 2, no. 1 (December 1992): 51-62.

[54]Glantschnig and Sekutowski, 7.

[55]Ibid., 7.

Fiksel[56] sees DFE as encompassing pollution and waste prevention, management of materials, risk analysis, life-cycle costing, and system-oriented design. In order to establish DFE as a systematic component of product development, he believes four key elements are needed: design metrics, design guidelines, design verification methods, and design decision frameworks to support system-level trade-offs.

Finally, a philosophical point on using DFE to design out the use of toxic materials is made by Glantschnig and Sekutowski:

> Typically, because of technology or process limitations, there are opportunities for reducing but not completely eliminating toxic materials. This being the case, should the designer attempt to minimize toxic materials, even if only relatively modest reductions are possible? The answer, assuming that the costs associated with the effort are not significant, is yes. Anything a designer can do to reduce the anthropogenic flows and emissions of toxic materials is worthwhile doing.[57]

2.4 Implementation

2.4.1 Implementation Literature and Models

Van Meter and Van Horn define implementation as, "Those actions by public and private individuals (or groups) that are directed at the achievement of objectives set forth in prior policy decisions."[58] Examining implementation involves looking at the degree to which planned activities or services are actually delivered. They recognize it is possible to deliver the planned services without having a substantial impact on the underlying problem. Thus, they make a clear distinction between the study of policy implementation and policy impact. Policy implementation deals with performance. Policy impact deals

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[56]Joseph Fiksel, "Design for Environment: An Integrated Systems Approach," Paper submitted to the First IEEE International Symposium on Electronics and the Environment, (Mountain View, CA: Decision Focus, 1993) 2-3.

[57]Glantschnig and Sekutowski, 10.

[58]Donald S. Van Meter and Carl E. Van Horn, "The Policy Implementation Process: A Conceptual Framework," Administration & Society 6, no. 4 (February 1975): 447.

with consequences. The difference, according to Dolbeare,[59] is that impact studies typically ask "What happened or what difference it makes?" whereas implementation studies ask "Why did it happen this way?"

Ripley and Franklin argue that implementation should be evaluated by looking at both performance and impact and they believe there are two principle means of evaluation:

> One is to ask whether the implementers comply with the prescribed procedures, timetables, and restrictions. The compliance perspective sets up a preexisting model of correct behavior and measures actual behavior against it. The second approach to assessing implementation is to ask how implementation is proceeding. What is it achieving? Why? This perspective can be characterized as inductive or empirical: there is a focus on what's happening and why. There are general references in this approach to what was expected or hoped for by different participants and observers, but there is no rigid preexisting model against which behavior is measured.[60]

This research uses a combination of both approaches. This is necessary since no one at DoD or HQ USAF is able to define what the "correct" methods are for implementing the pollution prevention program. Evidence for this is found in the Air Force's action plan that calls for defining policies, procedures, training, contract provisions, and Federal Acquisition Regulations that are needed to institutionalize[61] pollution prevention. A pollution prevention implementation framework is developed in Chapter 3, but the framework does not prescribe procedures, timetables, or restrictions. The framework does provide guidelines on substantive and procedural issues necessary for success, however.

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[59]Kenneth M. Dolbeare, "The Impacts of Public Policy," Political Science Annual: An International Review, (1974): 93.

[60]Randall B. Ripley and Grace A. Franklin, Bureaucracy and Policy Implementation, (Homewood, IL: Dorsey Press, 1982), 10.

[61]Institutionalize implies that the processes are known and understood and that the task involves merely changing administrative procedures. Since no one knows what changes are needed, the task is much more difficult that the action plan wording implies.

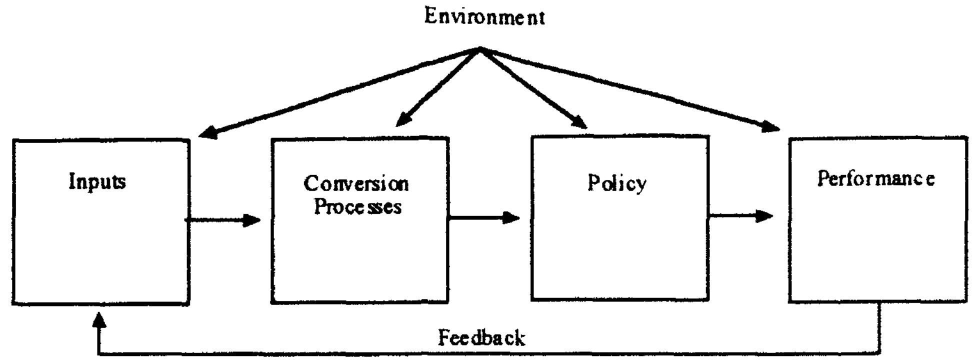

Figure 2.3. The Policy Delivery System

Sharkansky proposed the model of the policy delivery model shown in Figure 2.3[62] that developed into what is now called the top-down model, the instrumental model, the developmental model, the pyramid model, and the hierarchy model in the literature. The top-down approach essentially starts the analysis with a policy decision by an agency or with the enabling legislation and then asks:

1. To what extent were the actions of implementing officials and target groups consistent with the policy decision?
2. To what extent were the objectives attained over time?
3. What were the principle factors affecting policy outputs and impacts?
4. How was the policy reformulated over time on the basis of experience?[63]

Van Meter and Van Horn then proposed a theoretical framework for studying implementation that consists of two factors: the amount of change involved and the extent to which there is goal consensus among the participants in the implementation process. Within this framework, they expand on Sharkansky's basic model by constructing a policy implementation model with six variables that shape the linkage between policy and performance: 1) policy standards and objectives; 2) resources; 3) interorganization communications and enforcement activities; 4) characteristics of the implementing

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[62] Ira Sharkansky, "The Analysis of Public Policy: Recent Additions to an Ancient and Honorable Literature," Midwest Journal of Political Science, 16 (May 1972): 327.

[63] Paul Sabatier, "Top-Down and Bottom-Up Approaches to Implementation Research," Journal of Public Policy, 6 (1986), 22-23.

agencies; 5) economic, social, and political conditions; and 6) the disposition of implementers.[64] The model is shown in Figure 2.4.

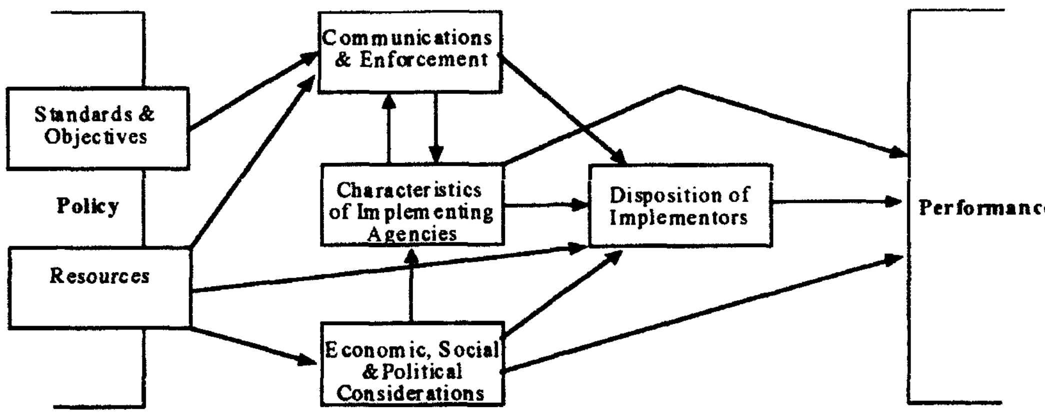

Figure 2.4. Van Meter and Van Horn's Policy Implementation Model

Other top-down models were proposed by Ripley and Franklin,[65] Edwards,[66] Sabatier and Mazmanian,[67] and others. The models differ greatly in the number of factors and how the factors interact, but they essentially keep the "policy-to-performance" framework changing only the number and the arrangement of the intervening factors.

As shown in Figure 2.4,[68] Van Meter and Van Horn proposed six factors. Ripley and Franklin suggested using five factors: 1) the large number of actors, 2) the multiplicity and vagueness of goals, 3) the large and complex mix of government programs, 4) the participation of numerous layers and units of government, and 5) powerful factors that

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[64]Van Meter and Van Horn, 458-474.

[65]Ripley and Franklin, 8-28.

[66]George C. Edwards III, Implementing Public Policy, (Washington D.C.: Congressional Quarterly Press, 1980), 9-14.

[67]Paul A. Sabatier and Daniel A. Mazmanian, "The Implementation of Public Policy: A Framework of Analysis," Effective Policy Implementation, (Lexington, MA: Lexington Books, 1981), 3-35.

[68]Van Meter and Van Horn, 463.

cannot be controlled.[69] Edwards suggested four factors: 1) communications, 2) resources, 3) dispositions of the implementers, and 4) bureaucratic structure. Sabatier and Mazmanian proposed seventeen factors. Le Breton proposed a planning-implementation model with many factors. He called them dimensions.[70] Unlike the some of the others, Le Breton resisted initially reducing the list of dimensions. Instead, he lists twenty dimensions that might be useful in different situations for understanding an implementation process. He then allows the dimensions to vary markedly in importance from situation to situation. His dimensions are listed in Table 2.2.

1. Complexity	6. Duration	11. Confidential Nature	16. Accuracy
2. Significance	7. Uniqueness	12. Clearness	17. Stability
3. Scope	8. Authorization	13. Formality	18. Legality
4. Comprehensiveness	9. Flexibility	14. Specificity	19. Morality
5. Frequency	10. Available Time	15. Completeness	20. Professional Etiquette

Table 2.2. Le Breton's Twenty Implementation Dimensions

Taylor[71] looked at how the National Environmental Policy Act (NEPA) was implemented in two federal agencies--the Forest Service and the Army Corps of Engineers. In his case study, Taylor organized his analysis around four factors: 1) interest group structure and the built-in conflicts; 2) the knowledge base; 3) leadership attitudes; and 4) formal organizational structure.

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[69] Ripley and Franklin, 9.

[70] Preston P. Le Breton, "A Model of the Administrative Process," Comparative Administrative Theory, ed. Preston P. Le Breton (Seattle: University of Washington Press, 1966), 169-178.

[71] Serge Taylor, Making Bureaucracies Think: The Environmental Impact Statement Strategy of Administrative Reform, (Stanford, CA: Stanford University Press, 1984), 41-71.

Thus, the number of variables thought to be important ranges from four to twenty but none of the models are adequate for predicting which factors are likely to be important in any given situation.

A second approach for studying implementation, often termed the bottom-up approach, was proposed by Elmore.[72] In contrast to the top-down approach, the bottom-up approach starts by identifying the network of actors involved and asks them about their goals, strategies, activities, and contacts. It then uses the contacts as a means for developing a network of actors involved in the area of interest. From the bottom-up perspective, performance is a consequence of the context in which implementation occurs.

Dunsire believes that implementation can be viewed as either a developmental (top-down) or an aggregative (bottom-up) process but, "For most purposes, the aggregative hypothesis will be the one that most often makes the most sense."[73] The aggregative hypothesis assumes that implementation is a purposive activity that requires identification of the requisite jobs, and the forging of the links in a network in a way that will produce the output intended. The developmental model, on the other hand, assumes a process that coincides with the progression of instructions, in different stages, from a superior to subordinates in an organizational hierarchy. Dunsire also calls the developmental model, the pyramid or hierarchy model, and the aggregative model, the network model.[74] He then uses two classics from the implementation literature to illustrate the differences. He places Downs'[75] work into the pyrmidal framework, and Pressman and Wildavsky[76] in to

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[72]Richard Elmore, "Organizational Models of Social Program Implementation," Public Policy, 26, no. 2 (Spring 1978), 185-228.

[73]Andrew Dunsire, Implementation in a Bureaucracy, (New York: St. Martin's Press, 1978), 226-227.

[74]Ibid., 84-85.

[75]Anthony Downs, Inside Bureaucracy, (Boston: Little, Brown, and Company, 1966).

[76]Jeffrey L. Pressman and Aaron Wildavsky, Implementation, How Great Expectations in Washington are Dashed in Oakland, etc., (Berkeley, CA: University of California Press, 1973).

the network image. Dunsire concludes that neither image--pyramid or network--will adequately portray all the relationships one observes.

Downs describes bureaus as having seven common internal characteristics: 1) a hierarchical structure of formal authority, 2) hierarchical formal communication networks, 3) extensive systems of formal rules, 4) an informal structure of authority, 5) informal and personal communication networks, 6) formal impersonality of operations, and 7) intensive personal loyalty and personal involvement among officials.[77]

Within this structure, Downs proposes a typology of goals, officials, and biases.[78] He divides the goals of each official into a hierarchy with five categories: 1) ultimate goals, 2) social conduct goals, 3) basic political action goals, 4) basic personal goals, and 5) specifically bureau-oriented goals. Officials are assumed to be rational, utility maximizers, that are also divided into five groups: climbers, conservers, advocates, zealots, and statesman--each type pursuing a different set of goals. The common biases of each official include: 1) a tendency to distort information that is passed upward, 2) a pattern of biased attitudes toward certain classes of policies, 3) a pattern of varying degrees of compliance with directives from superiors (they will zealously expedite some orders, carry out others with mild enthusiasm, drag their feet on others, and completely ignore a few), and 4) display different degrees of willingness to accept risks or seek out additional responsibility. Downs then uses these concepts to make a number of hypotheses about the behavior of officials, communications, control, and decision making in bureaucracies.

Pressman and Wildavsky, in their analysis (a case study) of an Economic Development Administration jobs program for Oakland, California, examine the chain of events that was necessary to implement the program. Their approach involves looking at

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[77]Downs, 49.

[78]Ibid., 85-87, 88-91, 77-78.

the organizations that were involved in the causal chain that was constructed to link objectives to actions. They explain this process stating:

> Considered as a whole, a program can be conceived of as a system in which each element is dependent on the other. Policies imply theories. Whether stated explicitly or not, policies point to a chain of causation between initial conditions and future consequences. Implementation is the ability to forge subsequent links in the causal chain so as to obtain the desired results. Once a program is underway implementers become responsible both for the initial conditions and for the objectives toward which they are supposed to lead. The longer the chain or causality, the more numerous the reciprocal relationships among the links and the more complex implementation becomes.[79]

Thus when a program fails, Pressman and Wildavsky recommend looking at both policy and implementation in seeking an answer. One possible explanation is the assertion of faulty implementation. Another appropriate explanation may involve the adequacy of the original policy. Aspirations may have been set too high or there may be a mismatch between means and ends. Perhaps implementation was good, but the theory on which it was based was bad.

In the Oakland case, Pressman and Wildavsky identify thirty decision points that involved seventy agreements that were needed for the program to succeed. Given this implementation network, the probability of successfully concluding each agreement would have had to have been exceeding high for there to be any chance at all for the program to be completed. They recognize, however, that few programs could be undertaken if all participants had to be specified in advance, all future differences resolved at the outset, and future bargains made under yesterday's conditions.

Given this limited ability to plan, some things must to be left to the unfolding of events. Then, as latent conflicts become manifest, the original plans have to be modified. An agency that appears to be a single organization with a single will turns out to be several suborganizations with different wills. The apparent solidity of original aims and

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[79]Pressman and Wildavsky, preface.

understandings gives way as people, organizations, and circumstances change. This situation is very similar to the third bias described by Downs. Pressman and Wildavsky go much further than Downs in their analysis by providing a series of seven potential reasons why participants may agree with the substantive ends of a proposal and yet still oppose (or merely fail to facilitate) the means for effectuating it.

1. Direct incompatibility with other commitments--Participants may agree with the merits of a proposal but find that it is incompatible with other organizational goals.
2. No direct incompatibility, but a preference for other programs.
3. Simultaneous commitments to other projects--Participants may agree with a proposal, have no contradictory commitments, and not prefer any alternative programs, but they may have other projects of their own that demand time and attention.
4. Dependence on others who lack a sense of urgency in the project--In the course of implementing a project, individuals or organizations may be called on because of their expertise or jurisdictional authority. Yet they may lack a sense of urgency about the overall program.
5. Differences of opinion on leadership and proper organizational roles--Participants who agree about a program's goals may nevertheless disagree about which people or organizational units should be running the programs.
6. Legal and procedural differences.
7. Agreement coupled with lack of power--Certain participants may agree enthusiastically with a proposal, but they may lack the resources to do much to help it.[80]

Beginning in the mid-1980s researchers began an effort to combine the bottom-up and the top-down frameworks into a single model. One model, the advocacy coalition framework, of Sabatier,[81] starts from the premise that the most useful aggregate unit of analysis is not a specific government agency, but rather a policy subsystem. The subsystem consists of those actors from both government and the private sector who are actively concerned with a policy problem or issue. The framework assumes that the actors can be aggregated into a number of advocacy coalitions who share a set of normative and

[80]Ibid., 87-124.

[81]Sabatier, 40-44.

causal beliefs on core policy issues. At an operational level, the policy results are mediated by a number of factors.

Stoker proposes a combined framework he calls the regime framework.[82] A regime is a political arrangement that institutionalizes values important in public decision making; but, a regime is also a set of organizational arrangements that help to define and support the political values inherent in it. Stoker sees the regime framework as uniting two "partial" models of the implementation process proposed by Allison,[83] the organizational process paradigm and the bureaucratic politics paradigm. "Thus, an implementation regime may be seen as an arrangement among implementation participants that identifies the values to be served during the implementation process and provides an organizational framework to promote those values."[84] Stoker goes on to explain how the regime framework differs from both the top-down and bottom-up approaches:

> From the regime perspective, the essential task of implementation is to create a context in which participants are likely to cooperate to achieve policy goals despite the absence of a dominating authority. Cooperation is not assumed to follow automatically from the mutual interests of implementation participants, so the implementation process is examined to determine whether context or mechanisms exist that enhance the incentives for cooperation. The emphasis on cooperation distinguishes the regime framework from established views of the implementation problem. Top-down approaches value compliance over cooperation. Bottom-up approaches focus upon conflict resolution, but fail to ask how implementation participants might realize their mutual interests through cooperation.[85]

Berman suggests that implementation be viewed as, not one, but two problems--a macro-implementation problem and a micro-implementation problem. The essential differences between the processes arise from their distinct institutional settings.

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[82]Robert P. Stoker, "A Regime Framework for Implementation Analysis: Cooperation and Reconciliation of Federalist Imperatives," Policy Studies Review, 9, no. 1 (Autumn 1989), 29-49.

[83]Graham T. Allison, Essence of Decision: Explaining the Cuban Missile Crisis, (Boston: Little, Brown, and Company, 1971).

[84]Stoker, 30.

[85]Ibid., 31.

> Whereas the institutional setting for micro-implementation is a local delivery organization, the institutional setting for macro-implementation is an entire policy sector, spanning federal to local levels. A policy sector usually consists of a collection of many diverse governments, bureaucracies, courts, public and private interest groups, local delivery systems, clients, and individual actors whose complex interactions are often hard enough to uncover, let alone describe. . . Nonetheless, policy sectors typically have tacit operating rules of the game, established roles, routinized procedures, and reasonably stable conditions. These enduring patterns of behavior can be called a macro-structure. . .
>
> The behavioral patterns among the public, private, and semipublic organizations and various actors in a policy sector can be seen as constituting a loosely coupled structure. Loose coupling, which is intended to be a neutral term in the sense that 'looseness' could be good or bad for implementation, suggests that (1) each organization has its own problems, perspectives, and purposes that reflect its particular structure and culture, and (2) each organization acts more or less autonomously within the overall macro-structure of the sector.[86]

Berman's framework fits the systems acquisition policy sector well. Further, after reviewing the implementation literature, it is clear that both the top-down (macro) and the bottom-up (micro) approaches are needed to explain implementation and that a satisfactory general model combining both approaches has yet to be demonstrated. Berman concludes that, "Because implementation, like other human problem-solving activities arises from the interaction of policy with its setting, we cannot anticipate the development of a simple or single retrospective theory of implementation that is context-free."[87] Since building a general implementation model is impossible in this view, Berman suggests that analysis be directed at developing institutionally grounded heuristics.[88]

For this investigation, implementation will be conceptualized using Berman's loosely coupled structure as the framework for analysis. This is appropriate given the seemingly limited ability of DoD and Air Force managers in Washington to control the activities of

[86]Paul Berman, "The Study of Macro- and Micro-Implementation," Public Policy 26, no. 2 (March 1978): 164-165.

[87]Ibid., 179.

[88]Ibid., 180.

the program offices as demonstrated in the acquisition literature. While some would argue that clear lines of authority exist, others argue that the military is really a form of organized anarchy made up of quasi-independent organizations.[89] In any case, the acquisition literature supports the view that both macro- and micro-implementation are important. Thus, Berman's macro- and micro-implementation structure will be employed using both bottom-up and top-down analysis techniques.

Finally, while there is no shortage of variables that have been proposed as important for explaining implementation, this research will begin by assuming two critical independent variables as suggested by Lester et al.[90] The policy itself being the first, and the setting (i.e., the people and organizations involved) being the second.

2.4.2 Setting Programmatic Objectives

Successful implementation of pollution prevention in system acquisition programs requires translating general pollution prevention goals, such as those in the Air Force Pollution Prevention Program, into specific objectives for each program. Setting specific objectives involves deciding what is important, how should it be measured, and setting target levels of achievement. The process for accomplishing this is an important element.

Hitch believes feasibility and cost must be considered when setting objectives. In discussing objectives for complex systems, he states, "It is impossible to define appropriate objectives without knowing a great deal about the feasibility and cost of achieving them. And this knowledge must be derived from analysis."[91] Applying Hitch's

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[89]Alan Ned Sabrosky, James Clay Thompson and Karen A. McPherson, "Organized Anarchies: Military Bureaucracy in the Future," Bureaucracy As a Social Problem, eds. W. Boyd Littrell, Gideon Sjoberg, and Louis A. Zurcher (Greenwich, CT: JAI Press, 1983), 37-53.

[90]James P Lester, Ann O'M Bowman, Malcolm L. Goggin and Lawrence J. O'Toole J., "Public Policy Implementation: Evolution of the Field and Agenda for Future Research," Policy Studies Review, 7, no. 1, (Autumn 1987), 210.

[91]C. J. Hitch, "On the Choice of Objectives in System Studies," Systems: Research and Design, ed. Donald P. Eckman, (New York: John Wiley, 1960), 44.

view to pollution prevention in weapon system acquisition, argues for early analysis in Phases 0 and I in order to arrive at an appropriate set of objectives prior to beginning design.

Oakley supports the need to incorporate objectives into detailed product specifications prior to starting design. According to Oakley, the product specification plays a central role in design.[92] Anthony stresses the importance of product specifications, but acknowledges the unique nature of each project stating,

> Although the specifications of one project and the method of producing it may be similar to those for other projects, the design is literally used only once. It follows that standards against which actual performance is measured are unique to the project (although reasonably reliable standards may be derived from experience on similar projects).[93]

While Anthony's comments concern measuring performance in general, others have addressed measuring pollution prevention specifically.

Craig, Baker, and Warren evaluated measures for assessing pollution prevention progress in the industrial sector. They concluded that, "No single measure of source reduction progress is accurate for all facilities and all wastes. Waste-generating activities and source reduction opportunities vary too greatly and too many factors affect the quantity generated. Therefore, multiple indicators are needed to assess pollution prevention progress."[94]

Andrews[95] asks, "What are we trying to measure?--overall national progress, local progress, physical amounts of wastes reduced, reductions in toxicity and other adverse

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[92]Oakley, 94-96.

[93]Robert N. Anthony, The Management Control Function, (Boston: Harvard Business School Press, 1988), 103.

[94]Jim Craig, Rachel D. Baker and John L. Warren, Evaluation of Measures Used to Assess Pollution Prevention Progress in the Industrial Sector, Research Triangle Institute, Center for Economics Research, (Washington D.C.: US Environmental Protection Agency, January 1991), 42. RTI Project Number 233U-4633-1 FR.

[95]Richard N. L. Andrews, "Research Needs for Waste Reduction," A workshop paper in Opportunities in Applied Environmental Research and Development. Committee on Opportunities in

effects, the efficiency of an industrial plant, or comparisons across plants, products, or economic sectors?" He concludes that, "No single number is useful for all these purposes; multiple measurements are necessary." In a related set of questions, he asks,

> Is waste reduction best pursued and measured by targeting specific "high-risk" substances throughout their processes of extraction and use (e.g., chlorofluorocarbons, lead, and chlorine); by targeting particular stages of the waste generation process (extraction, manufacturing, commercial use, and waste management); by targeting particular sectors, industries, or firms that are especially wasteful, especially hazardous, or especially attractive for opportunistic waste reduction; or by targeting product characteristics and specifications?

The Air Force policy does not answer these questions. The policy goals are not specific in either the Air Force policy or the DoD policy. Thus, compliance is not sufficient for understanding implementation. Given the broad array of projects the Air Force pursues, the range of industries and technologies involved, and the various levels of development from off-the-shelf commercial products to the design and manufacturing of state-of-the-art hardware, the pollution prevention objectives applicable to individual projects will, of necessity, have to be individually determined. The process for setting programmatic objectives is, then, an important element in the implementation process.

2.4.3 Environmental Impact Analysis

One process for identifying important environmental issues is already in use. Every acquisition program must accomplish a programmatic environmental analysis as required by the National Environmental Policy Act (NEPA). The analysis begins immediately after Milestone I, Concept Demonstration Approval, and is to be integrated with other plans and analyses for the program.[96] What role can or should NEPA analysis play in pollution prevention?

Applied Environmental Research and Development, Board on Environmental Studies and Toxicology, Commission on Geosciences, Environment, and Resources, National Research Council (Washington D.C.: National Academy Press, 1991), 26.

[96]DoDD 5000.2, 6-I-4 to 6-I-5.

The Council on Environmental Quality addressed this issue stating:

> The very premise of NEPA's policy goals, and the thrust for implementation of those goals in the federal government through the EIS process, is to avoid, minimize, or compensate for adverse environmental impacts before an action is taken. . .Including pollution prevention as an issue in the scoping process would encourage those outside the federal agency to provide insights into pollution prevention technologies which might be available. . .Pollution prevention should also be an important component of mitigation. . . CEQ encourages federal agencies to consider pollution prevention principles in their planning and decisionmaking processes in accordance with the policy goals of NEPA Section 101 and to include such considerations in documents prepared pursuant to NEPA Section 102, as appropriate.[97]

In a footnote to their statement, CEQ states, "As a guidance document, this memorandum does not impose any new legal requirements on the agencies and does not require any changes to be made to any existing agency environmental regulations." Thus, the choice on whether and how to including pollution prevention in NEPA documents is left to each agency.

In his study of National Environmental Policy Act (NEPA) implementation in the Forest Service and the Corps of Engineers, Taylor[98] observed that the government is responsible for protecting the environment, but government agencies all too often cause environmental damage as a "side effect" of their enthusiastic pursuit of programmatic goals. Some of this environmental damage is unforeseen; some, with present-day knowledge, is unforeseeable. But a great deal may be unnecessary to the achievement of organizational goals, and much would be considered an excessive price for the proffered benefits by nearly everyone except the agency and its direct beneficiaries. Much the same can be said about integrating pollution prevention in system acquisition programs. How can we do better?

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[97]Deland, "Pollution Prevention and the National Environmental Policy Act".

[98]Taylor, 1.

Taylor's view is that the answer to this question centers on the social intelligence that goes into environmental decisions. Not: "What is the 'correct' balance when trade-offs must be made between environmental and economic values?" But rather: "How can the social thinking necessary for intelligent trade-offs between different goals be institutionalized?" He saw the issue as not one of merely using technically better information for decision making, but one of how we fashion political and administrative institutions and processes.

His primarily hypothesis was that a well-structured analysis process--an analytical competition among government agencies and private groups that is regulated by certain kinds of rules--could aid decision making. To support his hypothesis, he lists eight generic "rules of analysis" that he believed were required for a system of formal analysis to work:

1. Focus analysis on important issues.
2. Specify how much detail must be provided for various kinds of analysis.
3. Prevent the manipulation of alternatives to obscure the real choices available.
4. Facilitate helpful criticism by informed outsiders.
5. Provide forums for resolving technical disputes.
6. Adjust the burden-of-proof rules or distribution of analytical resources to make the system workable if the resources of outsiders and insiders are greatly out of balance.
7. Provide incentives for the analysis actually to be used in decision making.
8. Encourage continual improvement of analytical methodology.[99]

In applying these rules to the environmental impact analysis process, Taylor asserts that the ideal EIS process must ensure integration of the analysts into the planning process. Integration is important in order to discover environmental problems early. The earlier the discovery, the greater the chance of modifying the design so as to avoid the damage, or to thoroughly investigating the alternatives that may meet both environmental and developmental goals more satisfactorily. Equally important, the earlier the discovery, the less likely it is that organizational commitment will rule out promising alternatives. On

[99]Ibid., 73-74.

the other hand, the information developed by the analysts should be in a form, of a kind, and timely enough to be decision relevant.

In studying the Corps, Taylor found that project managers often did not want to spend money on environmental analysis in the early phases project planning, before being confident of the economic benefits and engineering feasibility. After the economic benefits had been roughed out, and the engineering problems solved in sufficient detail to make a good case for the project, the project manager was willing to deal with the remaining problems. By that time, however, the alternatives and preferred solutions had already been formulated, and the environmental unit was less likely to have much effect.[100]

This process severely undercut the NEPA spirit because the full range of alternatives were not considered while the organization was still uncommitted to particular solutions. At its best, it gave the environmental analysts a "veto" of the favored solution, but it made implementation of their veto harder because options that might have been less environmentally damaging were not studied in the requisite depth. By the mid-seventies, Taylor documented that this "engineer-study-before-environmental-veto" arrangement had proved unattractive to the organization's leadership and had been overcome in the development agencies he studied.

The same cannot be said for the systems acquisition process. While NEPA documents are prepared to support each milestone decision, the documents do not address basic pollution prevention issues. For example, the environmental assessment for Milestone II, Engineering and Manufacturing Development (EMD), for the F-22 Advanced Tactical Fighter (ATF) documented the environmental impacts associated with proceeding to phase II. For the F-22, this includes activities associated with final design of the system and its manufacturing processes and flight testing a limited number of pre-production models. At the time the environmental assessment was prepared, two

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[100]Ibid., 95-96.

prototypes had been built and flown during phase I demonstrating most of the aircraft's technologies and materials. The impacts associated with flight testing were well documented. Those associated with system and manufacturing design were limited to building the test aircraft. No analysis of alternative materials or manufacturing processes was undertaken--even though these issues will have profound impacts on the types and quantities of releases that will occur later in the system's life cycle, especially during manufacturing and during aircraft maintenance.

The environmental assessment does not address design. Concerning manufacturing, the environmental assessment states:

> The stated policy of the manufacturers of the ATF aircraft and engines is to control all phases of operations to ensure compliance with environmental standards and regulations with regard to the use, handling, storage, and disposal of hazardous waste. Furthermore, all manufacturing will comply will the spirit and intent of federal, state, and local laws, regulations, and ordinances.
>
> Manufacturing of the ATF EMD aircraft will represent a small fraction of the total production expected at each of the manufacturing sites. Relatively few new processes will be involved in production of the ATF EMD aircraft, requiring the use of a small number of nonstandard materials and chemicals. Nonstandard materials are primarily graphite-based composites (toughened bismaleimides) amounting to some 6,000 lb./aircraft. All chemicals will be purchased and stored in small quantities (several gallons). The incremental change in production at the manufacturing sites caused by the ATF is not-considered to be a significant impact.[101]

While the information in the EA is both necessary (under NEPA) and relevant to the Milestone II decision, it was the only environmental information presented to the decision maker. Thus, one of the central issues in this research involves how and when pollution prevention analysis should occur and how the resulting information should be presented for milestone decisions.

[101]US Air Force, Aeronautical Systems Division, Advanced Tactical Fighter Full-Scale Development Environmental Analysis, (Wright-Patterson Air Force Base, OH: US Air Force, 22 April 1991), 4.1.

Finally, Taylor addresses the high potential for litigation based on NEPA to delay projects--destroying the usefulness NEPA documents. Taylor cites Bardach and Pugliaresi's ("The Environmental Impact Statement vs. the Real World," Public Interest, Fall 1977, pp. 22-38.) argument that the potential for litigation makes NEPA documents so legally defensive in format and substance that they are worthless to decision makers. Bardach and Pugliaresi also argue that removing the legal liability would make environmental impact analysis documents more useful to decision makers.

Their argument has a certain ring of truth within the Air Force. In discussing how NEPA documents could be used to present pollution prevention information for systems acquisition programs, some Air Force environmental officials have opposed the idea arguing that it would only give "ammunition" to those who oppose Air Force programs. If the NEPA process is to be useful for setting and measuring pollution prevention objectives, the internal desire not to go beyond minimum requirements must be overcome.

CHAPTER III

AN IMPLEMENTATION FRAMEWORK FOR POLLUTION PREVENTION IN SYSTEMS ACQUISITION

3.1 Introduction to Pollution Prevention in Systems Acquisition

Until recently, most pollution prevention activities have focused on reducing the environmental impacts associated with existing products and processes--and have often been successful. As a result, there is a well-understood analytical process for identifying and evaluating pollution prevention opportunities in operational facilities.

A typical pollution prevention analysis for an existing process begins with an organizing step and then proceeds to an assessment phase. During the assessment, information is gathered on the materials, processes and facilities. By the end of information gathering all of the needed data is readily available.

The problem with this approach is that large investments in plant and equipment are often already in place. This serves to greatly reduce the number of economically viable pollution prevention options.

At the beginning of an acquisition program, almost none of the information used in a traditional pollution prevention analysis is available. The challenge in systems acquisition is to incorporate basic pollution prevention principles into the system requirements and design processes from the earliest stages of the development process before investments are made--to achieve "pollution prevention by design."

The pollution prevention framework developed in this chapter addresses requirements for integrating pollution prevention into the systems acquisition process. In

achieving the desired integration, both substantive and procedural issues are important.[1] The framework addresses both types of issues by considering three overlapping processes and sets of requirements: pollution prevention, system design and engineering, and environmental impact analysis.

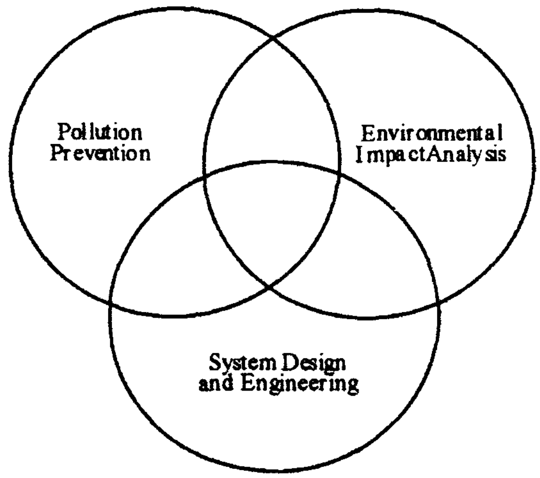

Figure 3.1. Components of the Pollution Prevention Framework

These key processes are shown in Figure 3.1. The need to integrate pollution prevention and system design and engineering is readily apparent. The role of environmental impact analysis is probably less apparent. The remainder of this chapter is devoted to building a pollution prevention implementation framework. The requirements for each process will first be addressed one at a time and then at the end of the chapter, brought together into an integrated framework.

[1]R. N. L. Andrews, "Environmental Impact Assessment and Risk Assessment: Learning from Each Other," Environmental Impact Assessment, ed. Peter Wathern (London, Unwin Hyman, 1988), 87.

3.2 Pollution Prevention in Systems Acquisition

What are the key principles of pollution prevention that must be integrated into systems development? This is the central question. Freeman et al.[2] identified four principles of pollution prevention:

1. Recognition of all activities involved in product and process design from extraction of raw materials to the ultimate fate of residuals.
2. Inclusion of environmental requirements at the earliest stages of product development.
3. Cross-disciplinary development teams.
4. Recognizing environmental impacts as measures of quality.

These principles address important substantive and procedural issues that surround pollution prevention practices and form the first leg of the pollution prevention framework. What do they mean in system development? Each principle is discussed below.

3.2.1 Recognition of All Activities in the Life Cycle (Life Cycle Focus)

This principle recognizes industrial ecology as a critical element in pollution prevention and has two major implications for system development. First, the boundaries for systems analysis must be expanded to include the full life cycle of all system materials and wastes. Second, and logically following from this, all prevention alternatives or options over the life cycle should be considered before selecting which combination of options will be employed.

While complete analysis of material life cycles and options sounds logical, it is difficult, in practice, to achieve. Early on in development little is known about either the final product or the processes that will be used to manufacture the product. In addition, important spatial information on where the system will be manufactured and used may not be known. Thus, early on in the process, the target effects of analysis are likely to be

[2]Harry Freeman, Teresa Harten, Johnny Springer, Paul Randall et al., "Industrial Pollution Prevention: A Critical Review," J. Air & Waste Management Association, 42, no. 5 (May 1992): 644.

defined in terms of potentially hazardous outputs (pounds of air emissions, gallons of wastewater, volume of hazardous waste, tons of solid waste, etc.) rather than in terms of impacts or risks.

During this early phase of a system's development, the designer's main task is to search for an acceptable set of design requirements that meet both the mission needs and the resource constraints. To provide useful decision information at this point in development, the environmental analysis must relate the given system performance and use requirements to the selected pollution prevention measures of merit. Currently, this is a crude process that uses expert opinion as the dominant data source.[3]

Because decisions are made incrementally throughout development, an increasing amount of information relevant for environmental analysis is generated over time. This results in the need to evaluate different opportunities for preventing pollution during different phases of development.

Varley recognized that like pollution prevention, the kinds of opportunities for improving reliability and maintainability also change over time during system development (see Figure 6). He wanted to know, "If we want to interact with the acquisition cycle, where are we most effective?" To answer this question, he looked at product innovation and process innovation and concluded that, "As you move towards advanced development where demonstrations, validations, and cost estimating are completed, new product alternatives decrease quickly as full-scale development begins and process innovation peaks."[4] Varley illustrated these two trends by graphing the relationship between product innovation and process innovation over the system life cycle.

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[3]Charles O. Coogan, "Front End Environmental Analysis," Paper presented at the International Symposium on Electronics and the Environment, Arlington, VA, 12 May 1993, (Piscataway, NJ: Institute of Electrical and Electronics Engineers, 1993), 132-137.

[4]Thomas C. Varley, "Reliability and Maintainability in the Acquisition Process," Reliability in the Acquisition Process, eds. Douglas J. DePriest and Robert L. Launer, (New York: Marcel Dekker, 1983), 9-10.

Similarly, opportunities for preventing pollution change over time as a system is developed. Fortunately, as illustrated in the next section, the design process is iterative. While this helps to some degree, Figure 3.2 illustrates that the focus of pollution prevention analysis must change over time so as to be relevant to the decisions that can still be influenced. Note that process innovation continues throughout the production phase indicating that manufacturing improvements can and should continue through the end of production and beyond. This conclusion is validated by the success of traditional pollution prevention activities that focus on manufacturing (acquisition Phase III).

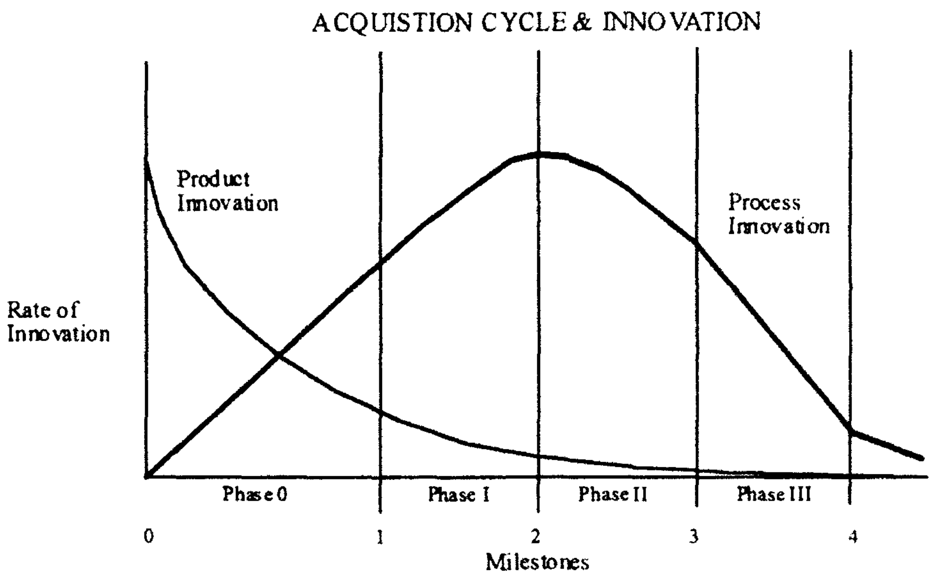

Figure 3.2. Relationship between Product Innovation and Process Innovation during the Acquisition Cycle

In seeking pollution prevention opportunities, the full range of alternatives should be considered. Potential pollution prevention strategies are displayed in Figure 3.3.[5] As shown, the strategies can be categorized into three general categories: source reduction, recycling, and treatment.

[5]US Environmental Protection Agency, Pollution Prevention Opportunity Assessment Manual. (Washington DC: US Environmental Protection Agency, 1991), 3.

Source reduction consists of product changes and source control strategies. The product change strategies correspond to the product innovation opportunities Varley was interested in. As illustrated in Figure 3.2, opportunities to impact basic product qualities decrease rapidly throughout Phases 0 and I to the point that few cost-effective changes can be made in Phases II and III.

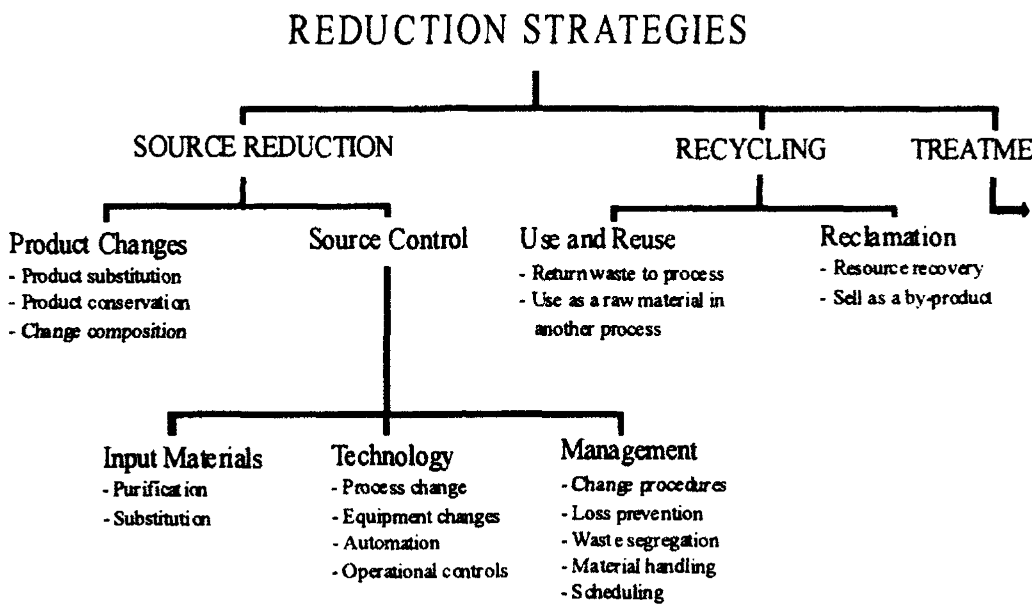

Figure 3.3. Pollution Prevention Techniques

Once an established production process is put in place, traditional methods for pollution prevention can be employed. Thus, the pollution prevention framework will primarily address acquisition phases 0 through II.

3.2.2 Include Environmental Requirements Early

This is a common procedural theme in both pollution prevention and environmental impact analysis. Two aspects of this principle are: 1) the need for early environmental analysis in the development process (i.e., starting in phase 0 and continuing throughout the process) and by inference the involvement of environmental professionals, and 2) the

translation of early analysis into specific design requirements that address important environmental issues. The key role played by the system specification was discussed in Chapter 2.[6]

Coogan, in adapting the logistics methodology of front end analysis to pollution prevention, echoes this saying, "The key to designing for the environment is in translating the adverse environmental impacts into design criteria, or relating design criteria to environmental impacts."[7]

3.2.3 Cross-Disciplinary Teams

As with including requirements early, the use of cross-disciplinary teams has long been a key procedural strategy in environmental impact analysis. DoD strongly embraces the use of cross-disciplinary teams in its concurrent engineering approach to system design and engineering. Thus, the issue in systems acquisition is whether the existing cross-disciplinary teams have a pollution prevention mandate and whether they include the needed technical specialists to address environmental issues.

3.2.4 Environmental Impacts are a Measure of Quality

The key to this principle is recognizing and including environmental indicators as measures of quality. Acceptance of this principle logically requires careful measuring, monitoring, and management of environmental measures of quality. Measurement is a key substantive issue for verifying that pollution prevention efforts produce real reductions in environmental impacts. As with cross-disciplinary teams, quality programs are already in place. What remains is adapting the DoD's total quality management (TQM) efforts to environmental issues.

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[6]See the discussions by Chase and by Freemen et al.

[7]Coogan, 133.

3.3 System Design and Engineering

The four pollution prevention principles discussed above must be integrated into systems acquisition, and more specifically into the system design and engineering process. System design and engineering includes acquisition phases I and II.

The systems acquisition process starts (Phase 0, Concept Exploration & Definition) with conceptual design studies that translates the system mission requirements into basic functional sequences of operations that describe how the mission can be accomplished. These studies must consider functional requirements, such as support equipment, facilities, personnel, logistics support, etc., from the outset to ensure that alternative concepts are feasible. In fact, by the time specific operational characteristics have been formulated into a preferred system concept, firm design approaches for the functional requirements will have already been largely determined.[8] The final output from Phase 0 is a system concept that includes mission requirements, performance goals, and a set of cost and schedule constraints.

Phase I, Demonstration & Validation, begins with the approved system concept. During Phase I, gross quantitative and qualitative measures for each functional requirement begin to emerge early in the process. As the analysis proceeds and decisions are made, more and more detail is considered until all operational, control, maintenance, support, production, assembly, integration, test, and deployment requirements are identified and a complete set of system design requirements is defined.

Phase II, Engineering and Manufacturing Development, starts with the system design requirements and concludes when the system and its manufacturing processes have been defined and tested.

The system design and engineering process transforms a set of mission requirements into a final system design. Thus, system design and engineering starts at the beginning of

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[8]Chase, 55.

Phase I, Demonstration and Validation, and continues until the end of Phase II, Engineering and Manufacturing Development. Figure 3.4 shows a simplified flow diagram of the system design and engineering process in Phases I and II.

Phase I is shown at the top of the figure and Phase II at the bottom.[9] The process is not a simple step-by-step process. Instead, the figure illustrates the interactive nature of the process. The figure also shows that the process consists of a series of complex decision problems that interact with each other. Finally, the figure illustrates the essence of the system design process--its goal being to synthesize a coherent system design that accounts for the many interacting requirements and constraints while ensuring that system components work together to attain the desired system capabilities when viewed as a functional whole.

Figure 3.4 also shows the major parts in the process. First, the possible applications of science and technology must be explored. Concurrently, the requirements must be made more explicit by developing performance-effectiveness criteria. These criteria are then incorporated into a model that can be used in trade-off studies. Functional requirements, such as availability, reliability, maintainability, safety, human engineering, and pollution prevention are used in conjunction with the system performance-effectiveness criteria for evaluating alternative system design approaches in trade-off studies.[10]

The results of these studies provide the principle information used in decision making at all levels of the program. The process of analyzing requirements and of conducting trade-off studies becomes progressively more refined and detailed as the process is iterated until a final design solution is reached.[11]

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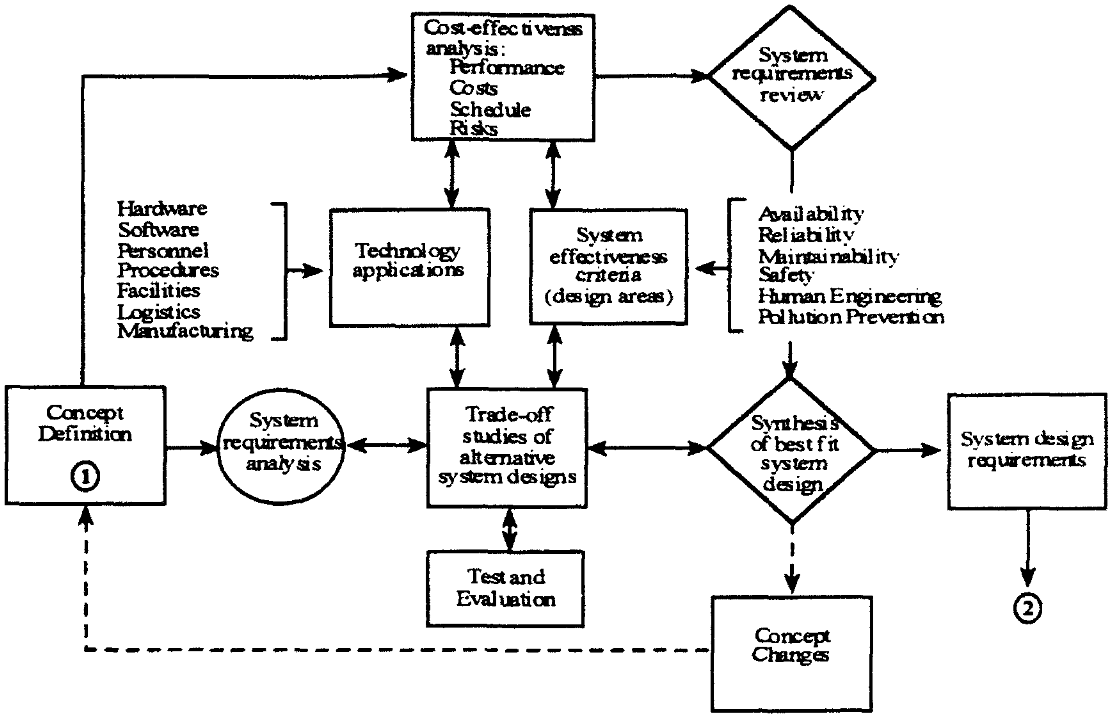
[9]Chase, 64a.

[10]Chase, 10.

[11]Ibid., 11.



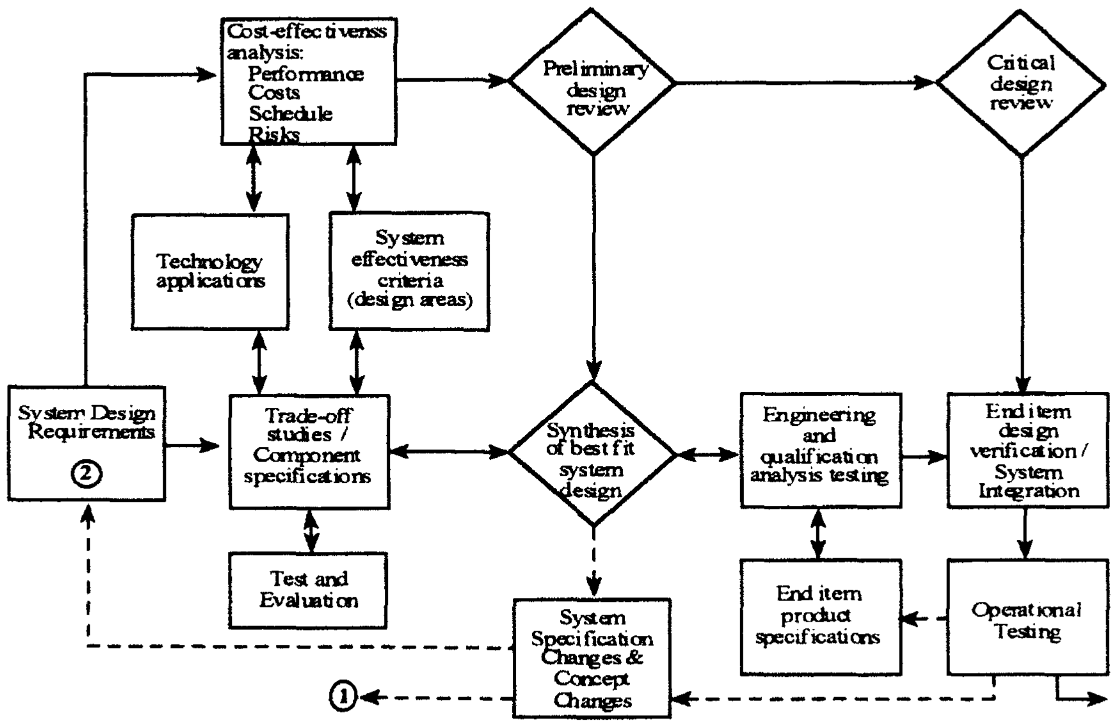


Figure 3.4. Simplified Systems Flow Diagram for Acquisition Phases I and II

The simplified system design and engineering process illustrated in Figure 3.4 can be conceptually further simplified as shown in Figure 3.5.

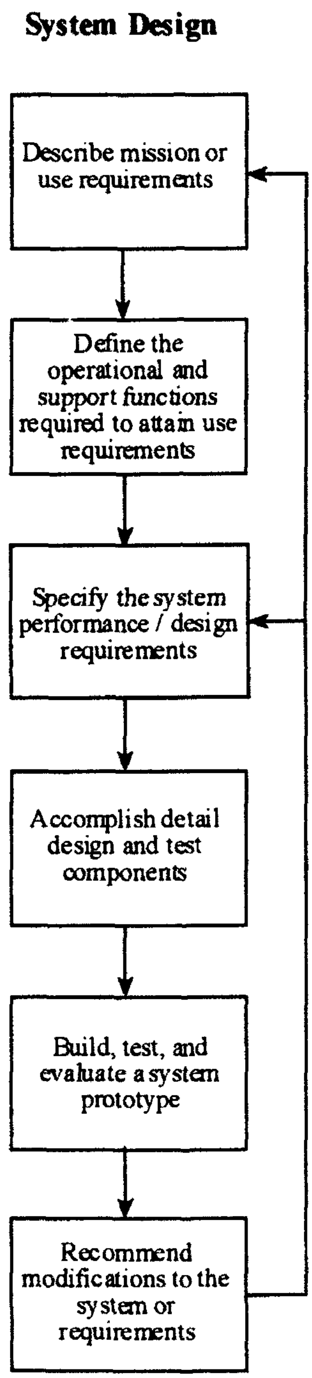


Figure 3.5. Conceptual System Design Process

This simplest model of the system design process is useful for understanding what steps (see Figure 3.6) are required to introduce a new variable into the system design and engineering process.

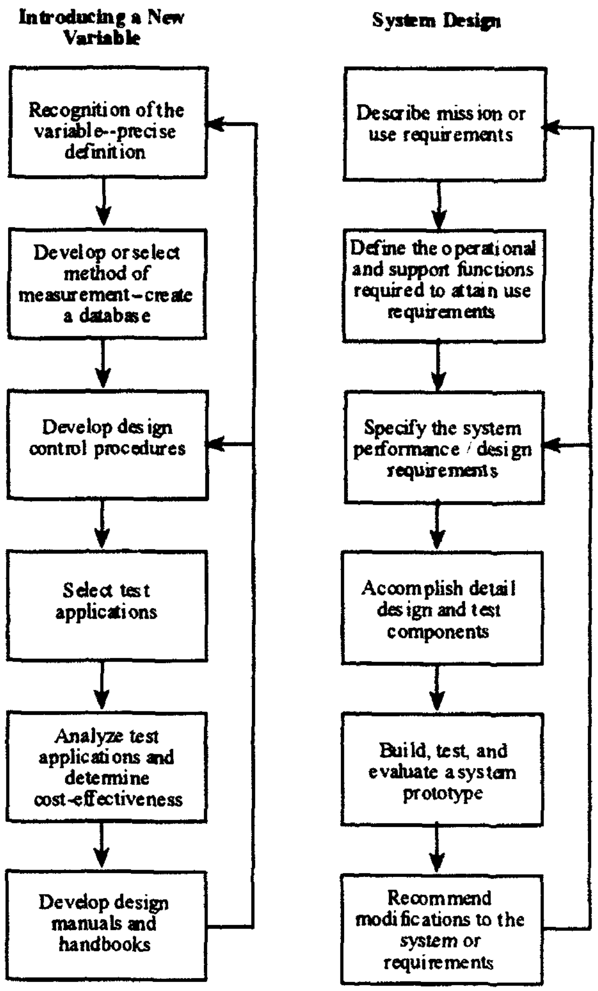


Figure 3.6. Steps for Introducing a New Variable in System Design and Engineering

The steps for introducing a new variable in the systems design process that are shown in Figure 3.6 are based on the six steps developed by Coutinho.[12]

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[12]John de S. Coutinho, Advanced Systems Development Management. (New York: John Wiley, 1977), 15.

1. Recognition of the variable to be controlled and its precise definition.
2. Development or selection of the methods of specification and of measurement, including the creation of an appropriate database.
3. Development of design control procedures.
4. Selection and performance of test applications.
5. Analysis of the test applications and determination of cost effectiveness.
6. Development of manuals and handbooks in support of general applications.

The steps are derived from the need to analyze the variable and to include it in decision making. Figure 3.6 shows Coutinho's six steps next to the steps in the system design process. The steps are similar. Thus, in addition to defining a logical process for considering a new variable during system development, the steps also serve as criteria for ensuring that substantive analysis takes place.

Within this framework, the first two steps are especially important for ensuring that real progress is made in reducing environmental impacts. Part of the process of selecting and defining a variable to be controlled involves identifying the problem of interest. The Office of Technology Assessment (OTA) lists identifying the root problem and defining it clearly as its first principle of green design.

> One of the biggest challenges. . . is clearly defining the problem to be addressed. One difficulty is that products and waste streams have multiple environmental impacts that cannot be easily disentangled. For example, policymakers may be concerned with the quantity of a particular waste stream, its toxicity, or its persistence in the environment. Policies aimed at solving a problem at one stage of the life cycle may have unintended negative effects at another stage: for example, requiring automobiles to be made from currently recyclable materials could adversely affect their fuel efficiency. Inevitably, tradeoffs and value judgments must be made as to which environmental impacts are the most important.
>
> . . . In the absence of a clearly defined problem, it becomes easy to confuse means and ends. . .for example, . . .the large quantity of municipal solid waste being generated. But a solution often put forward is to mandate higher recycling rates--as if the problem was that recycling rates are too low. The figure of merit for measuring progress then becomes higher recycling rates, instead of less waste generated.
>
> This approach misses the point that recycling is only one of several means to reduce the quantity of solid waste destined for disposal. Perversely, an exclusive emphasis on recycling could even lead to more waste being generated, especially if such emphasis discourages designs featuring waste prevention. . .

> Without a clearly defined problem, these is a tendency to focus on the most visible environmental issue, rather than those that are the most important. . .
>
> A clearly defined problem can also help to set priorities. For example, although the dissipation of toxic materials in the global environment is a growing problem, not all toxic chemicals and products are of equal concern. . .[13]

As OTA's analysis of green design shows, achieving "real" progress in preventing environmental impacts requires a clear problem definition and a clearly defined measure of merit. Measurement on a system basis is a difficult task, however. "How do we measure the environmental impacts of alternative systems, as opposed to alternative products? Product characteristics are tangible and can--at least in principle--be quantified through life-cycle analysis; system characteristics are less tangible."[14] In spite of the measurement difficulty, OTA firmly backs a system-oriented approach to green design.

> From an environmental perspective, it is simplistic to view products in isolation from the production and consumption systems in which they function. Is a fuel injector, for instance, a green product? From the vantage point of its component materials, probably not. But since it is designed to improve automobile fuel efficiency it could be considered "green" from a broader "systems" perspective.[15]

Since the introduction of pollution prevention into system development is relatively new, how much progress should we expect? Coutinho does not directly answer this question, but he provides some insight from past experience.

> The development of every new variable in the system development process follows this procedure. For example, in addition to weight control, the analysis of the static strength of airframes has completed this cycle. Stress analysis today is such an accepted design control activity that it is difficult to remember that its application was a very controversial subject as recently as 1930.
>
> Many currently important variables have not yet completed the full cycle of the six steps noted above. In strength analysis, the full cycle can only be associated with static loads. . . .Although the fatigue problem has been studied for over 100

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[13]US Office of Technology Assessment, Green Products by Design: Choices for a Cleaner Environment, (Washington D.C.: US Government Printing Office, September 1992), 113, OTA-E-541.

[14]Ibid., 62.

[15]Ibid., 54.

years. . .a generally validated and accepted data base and design manual still does not exist.[16]

Before moving on to look at environmental impact analysis, the question of how the current design for environment (DFE) literature fits the framework will be addressed. As summarized in Chapter 2, Fiksel proposes that four requirements must be met in order to establish DFE as a systematic component of product design: 1) design metrics, 2) design guidelines, 3) design verification methods to review and assess proposed designs with respect to the metrics, and 4) design decision frameworks to support system-level trade-offs between other inter-related quality metrics. Fiksel's list is essentially the same as Coutinho's framework, except that Fiksel does not explicitly include Coutinho's first and forth steps (although these two steps are implied). In addition, Coutinho's last step involves manuals and handbooks whereas Fiksel speaks of decision frameworks. In essence, however, the different terminology is really stating the same idea: standard decision approaches must be developed and accepted. Coutinho sees this as being accomplished when standard handbooks are recognized and routinely used.

Allenby describes DFE as a practice by which environmental considerations are integrated into product and process engineering design procedures.[17] He describes DFE as, "A subset of an existing design system known as 'Design for X', or DFX where 'X' is the desired characteristic such as testability, manufacturability, reliability, serviceability, or safety."[18] Subsets of DFE include design for disassembly, design for remanufacture, and design for recycling.

Allenby describes DFE implementation in terms of two components: a generic set of design practices, that can be implemented according to each firm's internal design

[16]Ibid., 15.

[17]Braden R. Allenby, "Design for Environment: Implementing Industrial Ecology," (Ph.D. diss., Rutgers University, 1992), 50.

[18]Ibid., 51.

practices and a national DFE information system (DFEIS).[19] Allenby's writing focuses on the DFEIS or data base (part of step 2 in Coutinho's framework). He defines the other steps needed for implementation in terms of a generic DFE template. He provides many key insights into the uses and problems associated with creation of a national data base, but clearly, the "generic DFE template" concept needs further development. As both Coutinho and Fiksel suggest (and Allenby acknowledges), a data base is important, but considerably more than a national data base is needed to make DFE a systematic component of product design.

Glantschnig and Sekutowski's methodology begins with a waste stream inventory and then proceeds to a proposed analysis based on two evaluation tools: a process data base and an impact data base.[20] These three concepts fit into Coutinho's first three points. The inventory and impact data base allow selection of the variables of interest and provide a means of measurement. The process data base can then be used to develop design control procedures.

As illustrated by these examples, Coutinho's framework provides a comprehensive way to evaluate which part of the implementation process each new contribution aims to fill and what is still lacking before the variable can be fully analyzed during system engineering and design.

As discussed, maybe the most fundamental problem in implementing pollution prevention is represented by Coutinho's first step--recognizing the variable of interest and precisely defining it. A complex system has thousands of potential environmental variables to select from. How are the important variables to be selected? The system design and engineering process is intended to find the best match between technical, engineering, and economic issues. Determining what is "important" (environmentally or otherwise) is not

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[19]Ibid., 57.

[20]Glantschnig and Sekutowski, 7.

solely a technical, engineering, or economic problem. Values, goals, and preferences are involved. One method for considering these issues is the environmental impact analysis process.

3.4 Pollution Prevention and the National Environmental Policy Act (NEPA) in Systems Acquisition

Pollution prevention and NEPA cover much of the same ground in that both attempt to identify actions that, if implemented, will reduce environmental releases and impacts.

In thinking about the relationship between pollution prevention and NEPA, a useful framework is to compare them substantively and procedurally. Andrews made a comparison between environmental impact analysis (EIA) and risk assessment (RA) using this framework. He summarized the substantive differences saying:

> It is clear that as substantive forms of analysis, EIA and RA, while differing in practice, are intrinsically similar in concept. An ideal example of each, in principle, could provide roughly comparable information. The output from both types of analysis is designed to clarify a decision maker's understanding of the alternative available courses of action and to present the best possible prediction of the significant consequences likely to result. Variations in EIA and RA, as currently practiced, represent differences in focus and emphasis. . .[21]

The same conclusion can be reached for pollution prevention and EIA (or NEPA). Most of the substantive differences involve focus and emphasis.

On the other hand, there are key procedural difference between EIA and RA. Andrews states that, "The most important difference between environmental impact and risk assessment, however, are differences not of substance, but of process."[22] The same is largely true of pollution prevention and EIA, although there are two areas of substantive differences.

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[21] Andrews, "EIA and RA," 92.

[22] Ibid., 92.

The first area of substantive difference is in the scope of impacts usually assessed. While EIA and pollution prevention both consider direct and indirect environmental impacts, energy requirements, and means to mitigate adverse impacts, EIA also considers areas such as natural and depletable resources, urban quality, and historic and cultural resources.

The second area of substantive difference involves the overall analysis objective. EIA is designed to support macro-level decisionmaking. In the system acquisition process, this corresponds to the major milestones. Pollution prevention, on the other hand, is concerned with micro-level decisionmaking. This difference is not as important in theory as it is in practice. The CEQ regulations require agencies to integrate the NEPA process with other planning activities at the earliest possible time (this is the way the regulations envision the process). When this is done in the systems acquisition process, pollution prevention can be seen as a subset of NEPA analysis. In practice, effective early NEPA analysis in the systems acquisition process appears to be rare. Part of the reason for this can be attributed to the procedural differences between EIA and pollution prevention.

To help clarify the procedural differences between pollution prevention and EIA in the systems acquisition context, another view of the systems acquisition process is useful.

Figure 3.4 illustrates the iterative nature of the system engineering and design process. In addition to an iterative nature, the system acquisition process also has a cyclic nature. This sense of the process is shown in Figure 3.7.

The acquisition process in Figure 3.7 begins with a statement of mission need and ultimately converges on a system design. Each loop in the spiral represents one cycle through the requirements/design process and concludes with an updated set of increasingly specific and integrated requirements. The first two loops correspond to acquisition Phases 0 and I. The final two loops in the model both represent parts of Phase II. The simplified

system engineering and design process shown in Figure 3.4, representing Phases I and II, corresponds to the second, third, and fourth loops in Figure 3.7.

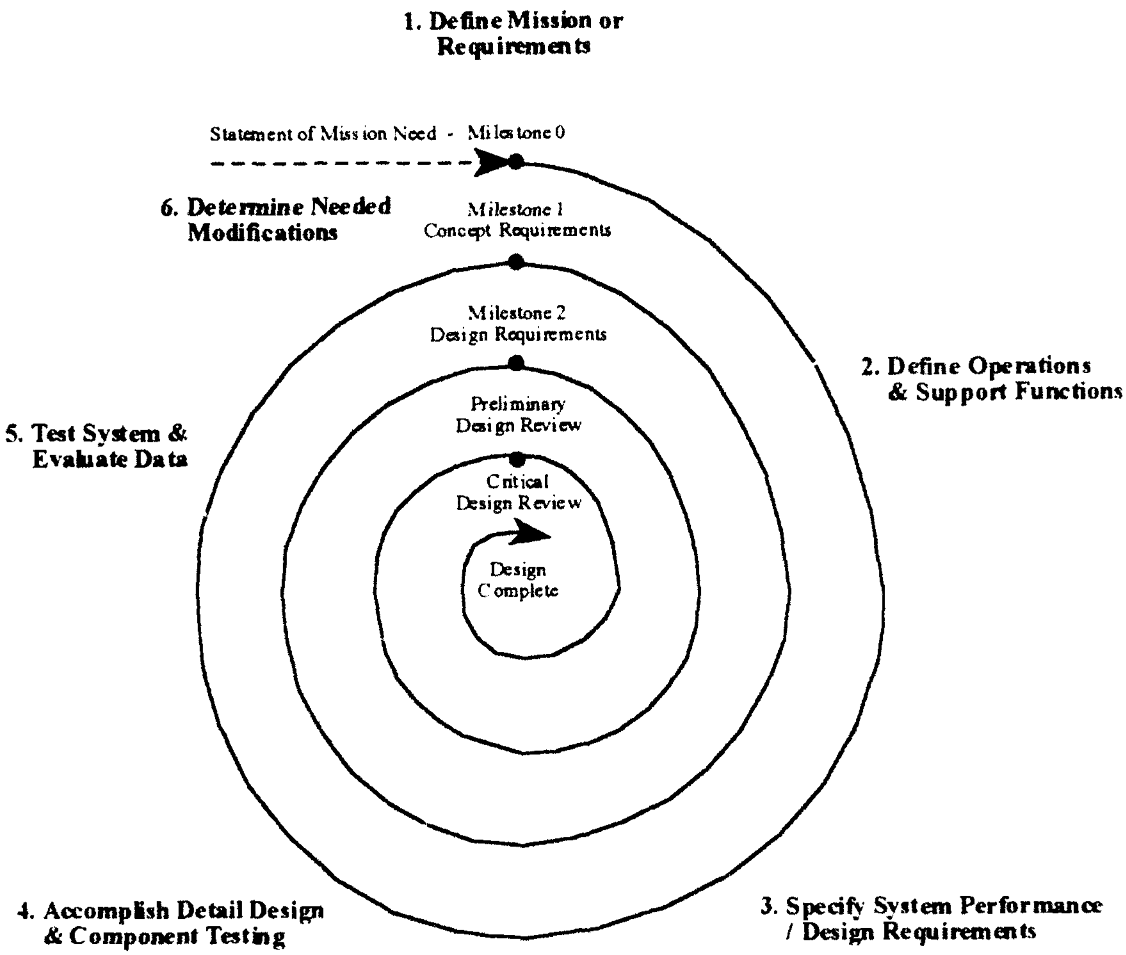


Figure 3.7. A Spiral Model of System Acquisition

The six steps in the system design process are shown around the outside of the spiral. These steps represent an ideal decision process that should support each decision that is made during each cycle. Since the overall process is made up of a series of related decision problems, a key for achieving pollution prevention during this process is to provide environmental input to decision makers that will allow them to make "good" decisions. This in turn requires integrating pollution prevention into each step in the system engineering and design process.

Given the large substantive similarities between NEPA and pollution prevention, how do pollution prevention and NEPA processes procedurally differ? There are two major area of procedural differences. First, NEPA analysis is required by law and has a set of defined procedure. Pollution prevention is not required by law and has no defined procedures. Second, pollution prevention can be fully integrated into systems engineering and design, while EIA cannot.

The prime contractor, who is responsible for conducting the systems engineering and design process, is prohibited from being the government's NEPA contractor by the Council on Environmental Quality's (CEQ) implementing regulations. The regulations require contractors to execute a disclosure statement, "specifying that they have no financial or other interest in the outcome of the project."[23] CEQ's guidance on this section of the regulations states:

> The purpose of the disclosure statement requirement is to avoid situations in which the contractor preparing the environmental impact statement has an interest in the outcome of the proposal. . . This requirement also serves to assure the public that the analysis in the environmental impact statement has been prepared free of subjective, self-serving research and analysis. . .
>
> Section 1506.5(c) prohibits a person or entity entering into a contract with a federal agency to prepare an EIS when that party has at that time and during the life of the contract pecuniary or other interests in the outcomes of the proposal.[24]

In systems acquisition, the development process (illustrated in Figure 3.4 and Figure 3.7) is largely carried out by an industrial team, led by a prime contractor. Since the purpose of the NEPA document is provide input on whether or not the acquisition program should continue on to the next phase, the entire industrial team has a substantial interest in the outcome of the decision. This excludes the entire team from direct

[23]Code of Federal Regulations, 40 CFR Part 1506.5(c).

[24]Council on Environmental Quality, "Memorandum: Guidance Regarding NEPA Regulations." Federal Register (22 July 1983) Vol. 48, 34265-6.

involvement in the EIA process and means that the EIA process must be conducted by people not involved in day-to-day decision making in the design process.

Given this restriction, the NEPA analysis is usually contracted to an independent contractor, but occasionally, the government accomplishes the work with government employees. This does not prevent the industrial team from providing information for the analysis and in practice this occurs regularly.

Figure 3.8 illustrates the relationship between NEPA and pollution prevention in the different organizational levels of a system acquisition program in DoD.

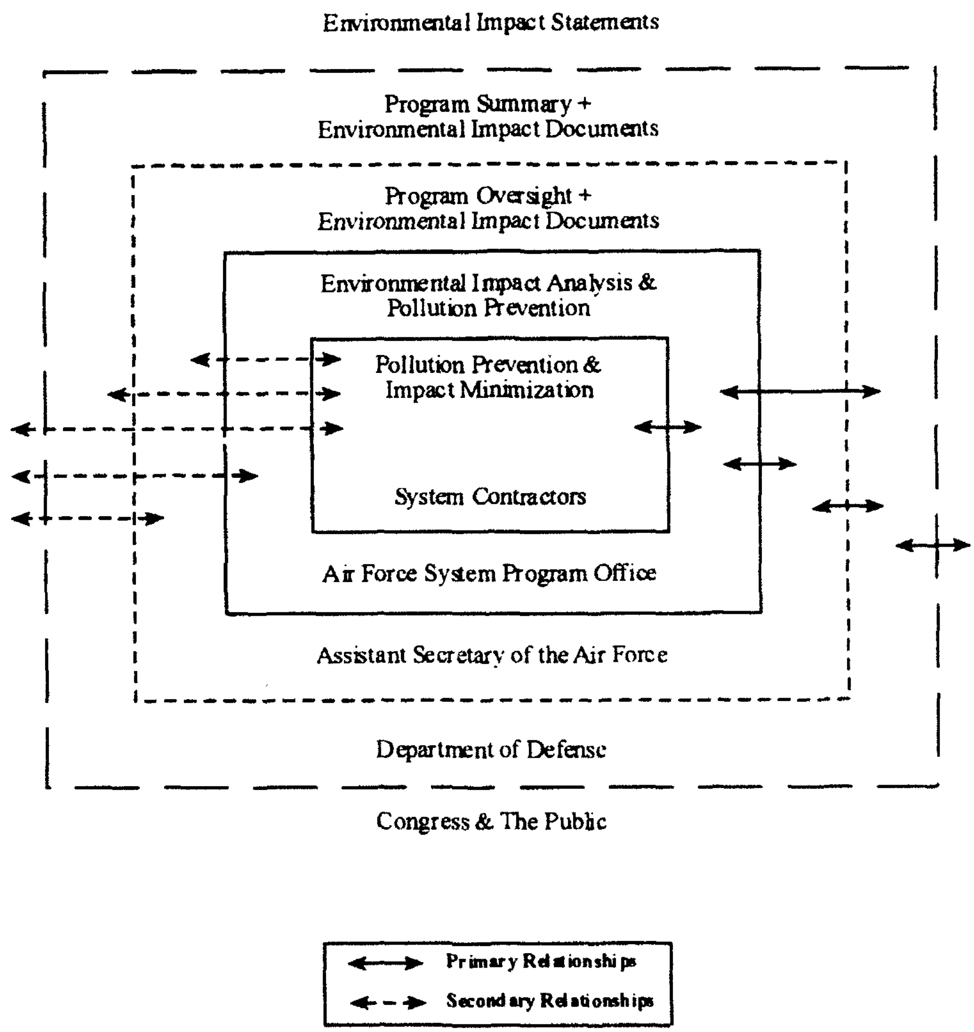


Figure 3.8. Relationship between Pollution Prevention and Environmental Impact Analysis in System Acquisition Programs

The system contractors are shown in the middle. As discussed above, they have no direct involvement in the NEPA analysis, but they are directly responsible for the system's environmental impacts in that they are responsible for the system design. Thus, their primary means of controlling impacts is to implement pollution prevention.

At the system program office (SPO), NEPA analysis is a primary environmental tool. The SPO also is directly involved in pollution prevention. The SPO sets the design criteria, approves trade-off studies, and conducts the design reviews.

As information flows outward from the SPO, the amount of information and its level of detail decreases. External to DoD, NEPA-mandated environmental impact statements provide one of the few sources of information available to the public.

In Making Bureaucracies Think, Taylor asks, "How can the social thinking necessary for intelligent trade-offs between different goals be institutionalized?"

> On the one hand, there is "science," learning without conflict of interest, on the other, "politics," the clash of interests without learning. . . .
>
> . . .NEPA is an attempt to change the intelligence capabilities of the federal agencies--the kind of information they routinely develop and the weight they routinely give it in their decisions. . . .
>
> In a nutshell, the argument of this book is that an arrangement much like the scientific community--an analytical competition among government agencies and private groups that is regulated by certain kinds of rules--is the key to improving organizational intelligence. . .[25]

In developing this hypothesis, Taylor identified eight generic "rules of analysis" that he believed were necessary to ensure a system of environmental analysis would provide the desired increase in organizational intelligence. The "rules" are derived from the methods science uses to advance knowledge.

1. Focus analysis on important issues.
2. Specify how much detail must be provided for various kinds of analysis.
3. Prevent the manipulation of alternatives to obscure the real choices available.
4. Facilitate helpful criticism by informed outsiders.

[25]Taylor, 3-4.

5. Provide forums for resolving technical disputes.
6. Adjust the burden-of-proof rules or distribution of analytical resources to make the system workable if the resources of outsiders and insiders are greatly out of balance.
7. Provide incentives for the analysis actually to be used in decision making.
8. Encourage continual improvement of analytical methodology.

Since integrating pollution prevention into the systems acquisition process requires the development of a new, but closely related, system of environmental analysis that is designed to improve decision making during system design and engineering, Taylor's rules provide a useful method for examining the policies and procedures that should apply to a system of pollution prevention analysis in the systems acquisition process.

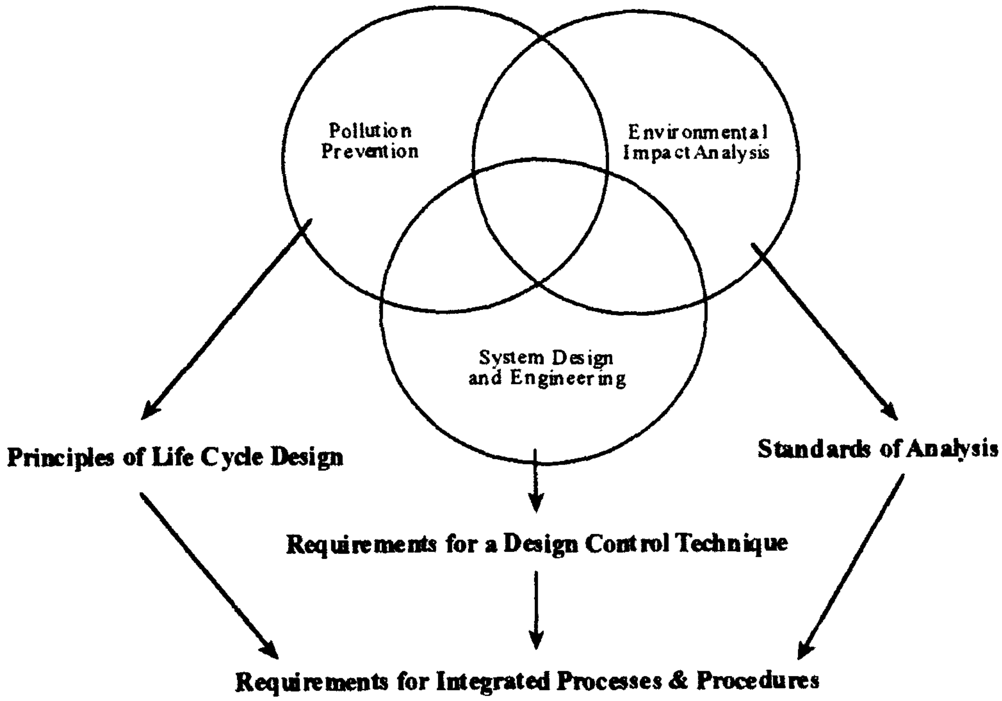
In addition, since pollution prevention and NEPA overlap in the systems acquisition process, it may be possible for the pollution prevention and NEPA processes to complement each other in meeting the "rules." For example, rules four and six both address analysis external to the acquisition process. Since system engineering and design is rarely open to outside analysis, it is it unlikely that pollution prevention analysis alone would meet this requirement. Perhaps NEPA analysis can help fill this void? On the other hand, pollution prevention has great potential to improve NEPA analysis for items one, three, seven and eight.

3.5 Pollution Prevention Framework

The pollution prevention framework brings together pollution prevention, system design and engineering, and environmental impact analysis concepts to form an integrated approach for pollution prevention in systems acquisition. The framework includes the key concepts from each area that are needed to produce an analytical system for achieving pollution prevention: 1) Pollution prevention--the principles of life cycle design, 2) System engineering and design--the requirements for a new system design control technique, and 3) Environmental impact analysis--the standards of analysis required for improving organizational intelligence.

The framework incorporating pollution prevention, system design and engineering, and environmental impact analysis (producing a combined set of eighteen criteria) is shown in Figure 3.9. The framework assumes that a fully successful pollution prevention effort requires coordination of the policies, procedures, and processes that govern each area in a way that supports a system of pollution prevention analysis that addresses both substantive and procedural issues by satisfying the combined set of criteria.

The strength of the pollution prevention framework is that it blends the substantive criteria needed for achieving and measuring "real" progress with the procedural criteria needed for the Air Force to learn over time by improving system-based pollution prevention design, analysis, and decision methods. With the framework description now complete, the research design is presented next.



Pollution Prevention - Principles of Life Cycle Design

1. Recognition of all activities in the product life cycle
2. Include environmental requirements early in product development
3. Cross-disciplinary teams
4. Recognizing environmental impacts as a *measure of quality*

NEPA - Standards of Analysis

1. Focus analysis on important issues
2. Specify how much detail for each kind of analysis
3. Prevent the manipulation of alternatives
4. Facilitate helpful criticism by informed outsiders
5. Provide forums for resolving technical diputes
6. Adjust burden-of-proof or distribution of analytical resources
7. Provide incentives for the analysis to be used
8. Encourage continual improvement of analytical methods

System Design - Requirements for Design Control

1. Recognition of the variable (precise definition)
2. Development of methods of measurement and a data base
3. Development of design-control procedures
4. Selection and performance of test applications
5. Analysis of test applications and cost-effectiveness
6. Development of handbooks to support general application

Figure 3.9. Framework for Pollution Prevention in Systems Acquisition

CHAPTER IV

RESEARCH DESIGN AND METHODS

4.1 Problem Summary

Neither the Air Force nor the Department of Defense (DoD) has instituted a comprehensive pollution-prevention policy framework that can be applied to system acquisition programs.

4.2 Research Questions

The research addresses three pollution prevention implementation questions:

1. **How is pollution prevention implementation proceeding?**
2. **To what extent--and how--are the pollution prevention framework criteria being met?**
3. **What revisions, if any, to existing pollution prevention processes, procedures, and policy are needed to better meet the pollution prevention framework criteria?**

4.3 Research Design

The research employs an embedded case study[1] of pollution prevention implementation to study the first two research questions. The case study looks at how pollution prevention is being implemented within the overall Air Force systems acquisition framework and involves several units of analysis. The main unit is the acquisition process

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[1]Robert K. Yin, Case Study Research: Design and Methods, (Newbury Park, CA: SAGE, 1989), 49-50.

as a whole. The smaller units involve pollution prevention implementation at four aerospace contractors that are involved in major Air Force acquisition programs.

The first and second research questions, which involve describing implementation, are addressed in a micro-implementation analysis of the subunits, and a macro-implementation analysis of pollution prevention in the systems acquisition. Then, the third research question, a policy-analysis question, is addressed in a bottom-up analysis, taking information from the case study to address the policy issues at a global (Air Force-wide) level.

The policy-analysis research, at the Air Force level of analysis, follows a rational-method approach. Specifically, the framework for value-focused thinking developed by Keeney[2] is being used as a guide. This method is essentially the same as the policy analysis process proposed by Patton and Sawicki.[3] As applied to the third research question, the general process involves five main steps:

1. Determine AF values and goals
2. Define the decision context and create decision opportunities
3. Develop alternatives
4. Evaluate the alternatives
5. Select an alternative

The initial phase of the policy research focused on the first two steps in Keeney's process; 1) determining the Air Force's values and goals for pollution prevention and 2) defining the systems acquisition context and creating decision opportunities. This information is needed for the macro-implementation analysis, as well as for the global analysis of policy.

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[2]Ralph L. Keeney, Value-Focused Thinking: A Path to Creative Decisionmaking, (Cambridge, MA: Harvard University Press, 1992), 29-98.

[3]Carl V. Patton and David S. Sawicki, Basic Methods of Policy Analysis and Planning, (Englewood Cliffs, NJ: Prentice-Hall, 1986), 17-39.

Air Force's values and goals were determined by first analyzing Air Force policy documents and the pollution prevention literature, and then interviewing the client. In all, four interviews were conducted. The first interview produced a preliminary set of values and goals. Following the initial interview, the values and goals were revised until the client was satisfied that the listing included all of the important decision elements. Addition information on the process used to identify the Air Force's pollution prevention values and a listing of the values are provided in Appendix A.

Defining the problem context involved reviewing the acquisition literature, observing the activities of the F-22 Advanced Tactical Fighter program, visiting contractor plants, and observing the acquisition process at DoD and HQ USAF.

4.4 Units of Analysis

While implementing pollution prevention in Air Force major system acquisition programs is of primary interest, aerospace companies were selected as the primary unit of analysis after the initial research showed that most pollution prevention activities are developed, implemented, and managed on a facility basis, rather than on a program basis.

Initially, all of the Air Force's, non-special access, programs were considered for this research. Based on interviews with program monitors at Headquarters, U.S. Air Force in the Pentagon, it was apparent that only a handful of programs had contractual requirements that address environmental issues. Initially, these programs were targeted for research and three were selected,[4] but obtaining sufficient information proved to be very difficult.

[4]The initial programs were the Joint Direct Attack Munition (JDAM) program, the Joint Primary Aircraft Training System (JPATS) program, and the F-22 Advanced Tactical Fighter program. As of the completion date of this research, neither the JDAM contract nor the JPATS contract had yet been awarded. The F-22 program, on the other hand, was an important part of the research. Of the four companies studied, three have major roles in the F-22 program.

In addition to the program specific information obtained in Washington D.C. and the program offices, an initial set of site visits to Lockheed Aeronautical Systems Company, Boeing Military Airplane Company, and Texas Instruments were conducted. At each site, the company environmental staff described their pollution prevention efforts and the majority of the initiatives were the result of efforts to reduce facility-based emissions. Organizationally, few environmental specialists were assigned to specific acquisition programs at these companies.

Based on this initial experience with obtaining case study information on a program basis and on the results of the site visits, it was clear that gaining an understanding of how pollution prevention is being implementing would require studying specific acquisition programs in the context of each company's overall environmental efforts.

4.4.1 Case Studies and Programs

In order to accomplish this, five major aerospace companies were selected for study where multiple programs could be observed. The five companies selected were:

1. Boeing Military Airplane Company,
2. General Dynamics, Fort Worth Division,
3. Lockheed Aeronautical Systems Company,
4. McDonnell Douglas Aerospace - East, and
5. Pratt & Whitney, Government Engines and Space Propulsion.

During the data collection phase of the research, Boeing decided not to participate and was dropped. In addition, General Dynamics sold the Fort Worth Division to Lockheed and it became Lockheed Fort Worth Company. Accounting for these changes, Table 4.1 lists the companies and programs that were studied.

Company	Programs
Lockheed Aeronautical Systems Company	F-22, C-130
Lockheed Fort Worth Company	F-16, F-22
McDonnell Douglas Aerospace - East	F-15, F/A-18, A/V-8B, T-45, A-12
Pratt & Whitney	F100, F119

Table 4.1. Companies and Programs Studied

4.4.2 Data Collection

Data was collected from five types of sources: DoD, Air Force and contractor documentation; archival records; interviews; questionnaires; and direct observation. All five sources were used at the companies listed in Table 4.1. In addition, information was gathered from the DoD and Air Force staffs. This information consisted of documentation, archival records, interviews, and direct observation.

4.4.2.1 Documentation

Documentation was used extensively. Sources include both government and contractor documents. Key documents include the contract statements of work, program plans, budget documents, minutes of meetings, staff reports, regulations, procedures, military standards, trade-off studies, etc. Both the government and the contractors provided relatively free access to program documents.

In addition, some documents that are external to the programs were used, such as EPA non-compliance reports and Toxic Release Inventory records, Securities and Exchange Commission quarterly and annual statements on the companies, corporate annual reports, and other public sources of data on the companies.

4.4.2.2 Archival Records

The use of archival records was more limited than the use of current program documents. Archival records were obtained primarily from the Air Force and DoD.

Access to corporate archival records was limited to those the contractors volunteered to provide.

4.4.2.3 Interviews

Intensive interviewing was an important form of information gathering in this research. In order to explain what is involved in intensive interviewing, this interviewing type will be categorized by structure, by scheduling, and by purpose.

The first dimension of a typology of interviews is the dichotomy between standardized and non-standardized interviews. Gordon describes the difference in terms of a set of interviews. "If all of the interviews in a set seek the same information, it is a standardized interview."[5] Public opinion polls are good examples of standardized interviews. In contrast, non-standardized interviews seek different information from each person in the set. Interview styles can then be seen as falling on a continuum between these two end points. Intensive interviewing falls in the middle of the continuum since both standardized and non-standardized information is sought. For example, questions on job titles and educational background seek standardized information. Open-ended questions on specific pollution prevention activities involve non-standardized information.

Another dimension of the typology of interviews is the dichotomy between scheduled and nonscheduled interviews. In a scheduled interview, the sequence, number, and wording of the questions are identical. In a nonscheduled interview these variables are allowed to change. Interviews in this research were nonscheduled even though a standardized interview guide was used. The guide served as an outline and the interviewees were encouraged to discuss the issues they believed to be important.

Finally, interviews are categorized by their purpose, such as problem solving, investigative, counseling, persuasion, etc. Two labels are often used to define non-survey

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[5]Raymond L. Gorden, Interviewing: Strategies, Techniques, and Tactics, fourth ed., (Chicago: Dorsey Press, 1987), 44.

policy and implementation research interviews: 1) intensive interviewing (the term adopted here) and 2) pattern interviewing. "The label of 'intensive' interviewing captures the thoroughness of the approach and the concerted effort required, not only to gather quality information, but also to collect lively quotations and interesting anecdotes."[6] Quay prefers the to call the approach "pattern interviewing."

> This approach is directive in that it focuses the interview on pre-selected areas or topics for discussion. It is non-directive in allowing the interviewee to explore each topic in any way he sees fit. The pattern interviews encourage the interviewee to express viewpoints and evaluations. Facts, supporting evidence, and supplementary data are solicited along the way as necessary or at the conclusion of each topical discussion.[7]

Prior to conducting the intensive interviews, four preparatory steps were taken. First, general context and background information was collected on each program and contractor. Data was gathered from documentation, records, observation, and in non-standardized interviews with selected members of the program and corporate staffs. Topics covered in these initial interviews included the organizational structure and listing of personnel, corporate policies and procedures, program management philosophy and control techniques, resource management, existing corporate environmental programs and their status, and the corporate record on environmental issues. The purpose of the initial interviews was to help structure a final interview guide for use in the subsequent intensive interviews. The information collected in the initial interviews was used to develop the final interview guide that is included at Appendix G.

In all, 65 interviews sessions were conducted. Some sessions involved more than one person. The sessions ranged from about 45 minutes to three hours in length. In

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[6]Allen D. Putt and J. Fred Springer, Policy Research: Concepts, Methods, and Applications, (Englewood Cliffs, NJ: Prentice Hall, 1989), 143, citing Jerome T. Murphy, Getting the Facts: A Fieldwork Guide for Evaluators and Policy Analysts, (Santa Monica, CA: Goodyear Publishing, 1980), 75.

[7]John Quay, Diagnostic Interviewing for Consultants and Auditors: A Participative Approach to Problem Solving, (Columbus, OH: Quay Associates, 1986), 8-9.

addition, many more people were contacted and provided information. During the course of almost every interview, the interviewee would suggest talking to another person to get additional information on specific issues. In some cases, these people were interviewed using the interview guide and are included in the total reported above. More often, time did not permit a "complete" interview. In these cases, a limited subset of questions was used that pertained to the specific information that was being sought. Each company also scheduled 15-20 minute sessions with senior executives at the company. Like the other "short" interviews, these are not included in the total reported above. Adding these short interviews and contacts to the total number of people interviewed brings the total number of people contacted during all of the site visits to approximately 200.

4.4.2.4 Questionnaire

A short questionnaire, consisting of twenty-six questions, was developed from recent national telephone surveys to help determine whether aerospace industry employees that implement pollution prevention have significant negative predispositions toward environmental issues. The research hypothesis is that attitudes toward the environment are the same for defense industry workers and the United States population.

In preparing to perform the survey research, a separate survey plan was developed. The plan addresses question selection, determining the minimum sample size required, sampling procedures, and data analysis techniques. The survey plan along with a copy of the data can be found in Appendix F. In all, 261 responses were obtained.

4.4.2.5 Direct Observation

Direct observation was used to both gather first hand information and to assess the quality of information provided by other sources. The form of direct observation used in this research can be described as transient observation.

> Transient observers combine observation with other research activities. They observe physical surroundings, events, and interpersonal interactions as they

> conduct interviews or work in agency offices while fulfilling other research activities. Transient observes take advantage of opportunities to be present at meetings or other relevant events which occur while they are on site.[8]

While these observations are useful in confirming information from other sources, improving understanding, and for providing new ideas, the information gathered must be used with care. Incorrect meanings to events and behaviors may be inferred. To avoid this, direct observations must be compared and complemented with other information.

Direct observation was used in three areas of this research: 1) at DoD to study the weapons acquisition process, 2) on the F-22 program, and 3) during the site visits to the four aerospace companies.

Three visits to the DoD staff were made that lasted approximately three days each. During the visits, the observer spent two days with a DoD staff member and followed the staff member's daily schedule with them including attending all meetings. While the observer was identifiable as being from the "outside," the opportunity to screen the information presented was small. During the final day of the visits, interviews with other DoD staff member were conducted and records and documents were gathered.

Direct observation was also used for the F-22 program. A number of program meetings totaling approximately 100 hours were observed and a separate two day site visit to the program office was conducted. The meetings were held at both Air Force and contractor facilities and occurred over about a 30 month period. Some of the meetings at the contractor facilities occurred before the contractor site visits and some occurred following the site visits.

During site visits, direct observation played a limited role do to time constraints. Each company's facilities were observed but the large number of interviews prevented attending more than one or two meetings at each site.

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[8]Putt and Springer, 160.

Overall, direct observation was important for gaining an understanding of the acquisition review process at DoD, but it provided only a supplemental form of information for the corporate case studies.

4.5 Analysis and Reporting

To ensure adequate information would be collected for analysis of the first two research questions, a list of relevant topics and questions was developed to help guide information gathering, analysis, and reporting. The questions were used to help draft the initial interview guide and the questionnaire and were used to help focus information gathering from the other sources. At the end of the data gathering step, information for addressing the questions came from all five sources of information. The topics and questions are listed below:

Policy

1. What are the government's pollution prevention objectives and how were they set?
2. What are the program's scope and key features?
3. What are the contractor's corporate environmental policies and pollution prevention policies?

Setting

4. What is the setting? (Structure of the organizations, both formal and informal? Economic, social, and political setting?)
5. How are the contractor's policies applied to other corporate activities?
6. What is the corporate record on environmental issues (non-compliance citations, Toxic Release Inventory data, etc.)?
7. Is there any quantitative or qualitative difference between what is done for the Air Force program and other corporate programs?
8. What is the difference?
9. What accounts for the difference?

Other Factors

10. Who are the participants?
11. What are the participant's goals?
12. What is the knowledge base?
13. What resources are available?
14. What are the constraints (rules, people, funds, etc.)?
15. What are the leaders attitudes?
16. How are the pollution prevention objectives being implemented?

17. How is success being measured and what are the results?
18. How are the pollution prevention objectives managed?
19. What information is available for decision making?
20. How are decisions made and reviewed?
21. What are the communication networks and how do they work?
22. How does the NEPA process interact with pollution prevention?
23. What are the problems encountered in implementation? What, if any, is the resolution?
24. Are there any unanticipated effects (desirable or undesirable)?

The analysis began by analyzing the individual subunits. To accomplish this, a separate case study was assembled for each of the four companies. The individual company case studies are included as Appendices B, C, D, and E.

Following the analysis of the subunits, the research questions were each analyzed and the results are presented sequentially in Chapters 5, 6, and 7. The global analysis found in these chapters was carried out using three primary techniques. First, a global analysis of the subunits using pattern matching logic among the subunits is accomplished. The goal was to identify the important processes, individual and organizational responses, and the common factors that provide insight into understanding how pollution prevention is being implemented. Second, the status of pollution prevention implementation on a global basis relative to the pollution prevention framework is summarized. Finally, based on these results, a global analysis of policy issues is conducted. The analysis addresses current policies and alternatives developed in the course of the case studies and subsequent analysis. The values criteria for evaluating the policies will be based on the pollution prevention framework.

CHAPTER V

POLLUTION PREVENTION IMPLEMENTATION IN THE AEROSPACE INDUSTRY

5.1 Introduction

The purpose of this chapter is to answer the research question: How is pollution prevention implementation proceeding? In order to answer this question, four large aerospace companies with major government contracts were studied between July 1993 and March 1994. Each company was first studied as an individual subunit and separate case studies were prepared. The case studies are located in the appendices as listed:

Case Studies	Appendix
1. Lockheed Aeronautical Systems Company	B
2. Lockheed Fort Worth Company	C
3. McDonnell Douglas Aerospace - East	D
4. Pratt & Whitney, Government Engines and Space Propulsion	E

Before beginning the detailed analysis of pollution prevention in the aerospace industry, a brief introduction to each company is presented. Then, the introduction concludes with an outline of the major topics that will be covered in the analysis.

5.1.1 Case Studies

Lockheed Aeronautical Systems Company (LASC), an operating company within the Aeronautical System Group of Lockheed Corporation, is major supplier of military aircraft and other systems. LASC's principle facilities at Marietta, Georgia are owned by the Air Force and operated by Lockheed. The government facilities are known as Air Force Plant 6 (AFP-6) and are situated on Dobbins AFB. The plant was constructed in 1943 and contains approximately eight million square feet of space. In recent years, the

C-130, C-141 and the C-5 military cargo aircraft and the Navy's P-3 maritime patrol aircraft have been assembled at AFP-6. When the F-22 enters production, it will also be assembled at AFP-6.

Lockheed Fort Worth Company (LFWC), like LASC, is an operating company within the Aeronautical System Group of Lockheed Corporation. Lockheed acquired the company from General Dynamic Corporation on 1 March 1993. LFWC builds the F-16 fighter and has a one-third share in development of the F-22. LFWC's principle facilities are part of Air Force Plant 4 (AFP-4) and are located on 602 acres adjacent to Carswell Air Force Base (AFB). Over the years B-24, B-32, B-36, B-58, F-111, and F-16 aircraft have been produced at the 7 million square foot plant. Currently only the F-16 is in production, but a portion of the facility is being prepared to produce center fuselage sections for the F-22.

McDonnell Douglas Aerospace - East (MDA-E) is a major business unit of McDonnell Douglas Corporation (MDC), a major supplier of military and commercial aircraft as well as missile, space and electronic systems. MDA-E includes all of MDC's St. Louis area operations and is responsible for most of MDC's military programs. This includes tactical aircraft, helicopters, and missile systems. The only major MDC military aircraft program not managed by MDA-E is the Air Force C-17 Globemaster III military transport. Aircraft currently in production include the F-15 Eagle, the F/A-18 Hornet, the AV-8B Harrier II, and the T-45 Goshawk.

Pratt & Whitney (P&W), a division of United Technologies Corporation, is a leading designer and builder of high-performance jet engines for commercial, military, and general aviation. The Government Engines & Space Propulsion (GESP) unit, located in Palm Beach County, Florida is responsible for military gas turbine engines, liquid rocket engines, sold rocket motors and space launch services. The GESP facility was opened in 1958 and is located in the western portion of the county, on the edge of the Everglades. In addition to the F119, being developed to power the Air Force's F-22 Advanced

Tactical Fighter, GESP is also responsible for the F100 family of engines that power the Air Force's F-15 and F-16 fighter jets; the F117, a military version of P&W's PW2000 series engine used on the new C-17 cargo plane; and the J52 engine that is installed in Navy and Marine Corps A-6 Intruder, EA-6B Prowler, and A-4 Skyhawk aircraft.

5.1.2 Organization

Table 5.1 shows an outline of the major areas that are analyzed and compared for each company. The areas of analysis are presented in four major sections.

Section	**Areas of Analysis**
5.2	Pollution Prevention Objectives, Strategies & Policies 1. Corporate 2. Operating Company
5.3	Pollution Prevention Paradigms 1. Design-materials 2. Compliance 3. Waste reduction
5.4	Implementation Contextual Factors 1. Organizational Structure 2. Communications 3. Resources 4. Dispositions 5. Decision Making and Management Procedures
5.5	Pollution Prevention Implementation
5.6	Summary, Conclusions, and Recommendations

Table 5.1. Areas of Analysis

The companies' pollution prevention efforts are analyzed starting with pollution prevention objectives, strategies and policies in Section 5.2. Following the policy section, pollution prevention paradigms are discussed in Section 5.3, implementation contextual factors are covered in Section 5.4, and pollution prevention implementation is detailed in Section 5.5. The chapter ends with conclusions and recommendations in Section 5.6.

5.2 Pollution Prevention Objectives, Strategies, and Policies

A strategic management framework will be used to examine the pollution prevention policies of each corporation and operating company studied. Since there are no generally accepted definitions for strategic management in the literature, this paper uses a composite of several common views of strategic management.

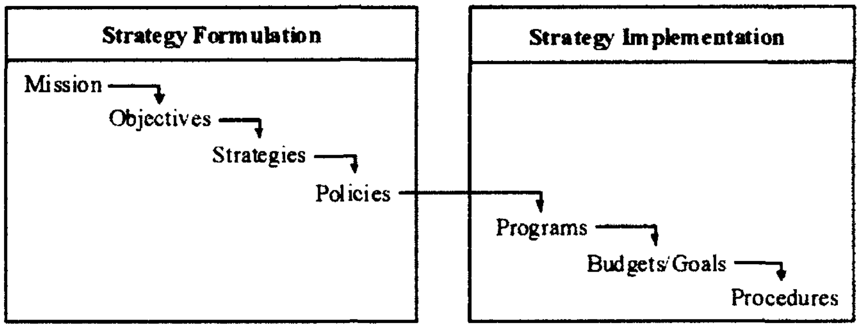

Figure 5.1 Strategic Management Model

Figure 5.1[1] illustrates the concepts of strategy formulation and strategy implementation. Strategy formulation refers to a hierarchical system of objectives, strategies, and policies. Strategy implementation includes establishing programs, plans, goals, and procedures and allocating resources to achieve the objectives.[2]

Rather than divide the individual strategic management steps into two categories (strategy formulation and strategy implementation), Schellenberger and Boseman divide the steps into three components: 1) establishing objectives, 2) planning programs of action

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[1]Thomas L. Wheelen and J. David Hunger, Strategic Management and Business Policy, 3rd ed., (Reading, MA: Addison-Wesley Publishing, 1989), 12.

[2]Objectives state what is to be accomplished on a strategic scale, should include the time frame for accomplishment, and be quantified if possible. Strategies describe how the organization will achieve its objectives and often address who will be responsible. Policies flow from the objectives and strategies and provide broad guidance for decision making throughout the organization. A goal refers to measurable level of desired performance that is to be achieved over a specific evaluation time frame. As used here, goals are tactical devices for implementing a program to reach the objectives. Objectives, on the other hand, are strategic in scope and should address multiple evaluation periods.

designed to reach the objectives, and 3) commitment of resources to carry out the plans.[3] This view is useful because of its emphasis on different types of objectives: basic objectives and means objectives.

Basic objectives are long term in nature and should provide a stable basis for corporate planning and action. Basic objectives include the product-mission statement, financial and profitability objectives, and social and psychological objectives.[4] This distinction is important because pollution prevention can be defined as a product objective, a financial objective, or a social objective, or as a combination of objectives.

Schellenberger and Boseman recognize that there is an inherent tension between profitability and social objectives. "Basically the problem is in deciding how much of a profitability trade-off the organization is willing to accept in order to ensure the fulfillment of its social or psychological objectives."[5] Since pollution prevention can be framed using different basic objectives, corporate pollution prevention policies play an important role in determining how pollution prevention policies will be implemented within the organization.

At 3M, the objectives of the "Pollution Prevention Pays" Program include strong financial and social components and to lesser degree, a product component. To receive formal recognition under the program, a project must meet four criteria:

1. It must, through process change, product reformulation, or other preventive means, eliminate or reduce a pollutant that currently is a problem or has the potential to become a 3M problem in the future
2. It should exhibit, in addition to reduced pollution, environmental benefit through reduction in energy consumption, more efficient use of raw materials, or improvements in the use of other natural resources.

[3]Robert E. Schellenberger and F. Glenn Boseman, Policy Formulation and Strategy Management, (Santa Barbara, CA: John Wiley & Sons, 1978), 8.

[4]Ibid., 16-17.

[5]Ibid., 21.

3. It should involve a technical accomplishment, innovative approach, or unique design in meeting its objectives
4. It must have some monetary benefit to 3M. This may be through reduced or deferred pollution control or manufacturing costs, increased sales of an existing or new product, or other reduction in capital or expenses.[6]

Note that the first and fourth criterion state that the project "must" while the second and third criterion use the word "should." Projects must be preventative in nature and they must have a monetary benefit to 3M. Since projects must meet both the financial and social criteria, the potential conflict between the program's financial and social components is minimized.

At Lockheed, environmental policy is stated as a social objective. Lockheed's policy is to be, "a good neighbor, employer, and corporate citizen by managing all phases of our operations to minimize adverse effects on the environment and the safety and health of our employees, customers, and communities surrounding our plants."[7] This policy, which is based on social objectives, is much different from the "Pollution Prevention Pays" objectives at 3M.

Means objectives describe the strategies and methods for achieving the basic objectives. Means objectives also can be divided into three categories (which parallel the categories for basic objectives) where the objectives address the maintenance or improvement of: 1) market positions, 2) the organization's resources, or 3) relationships with the internal or external organizational environment. As a means objective, pollution prevention can be framed in terms of any or all of the categories. For example, "green" products may be developed in response to a perceived market for them; or as at 3M, to reduce the overall level of resources needed to meets the company's environmental responsibilities; or as a means of being a good neighbor. Participation in EPA's 33/50

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[6]Thomas W. Zosel, "How 3M Makes Pollution Prevention Pay Big Dividends," Pollution Prevention Review, (Winter 1990-1991): 68-69.

[7]R. A. Fuller, Vice Chairman of the Board and Chief Operating Officer, "Environmental, Safety, and Health Protection," Management Policy Statement Number 173, (Calabasas, CA: Lockheed Corporation, 13 November 1989), 1.

Program might be undertaken as part of a corporation's social objective to be a good neighbor, or as a means to improve its relationships with environmental regulators or environmental groups, or as a means for saving money by reducing waste.

Using this analysis framework, one should expect environmental policy statements at the corporate level to always include statements on basic environmental objectives and depending on the corporate management philosophy and organizational relationships,[8] sometimes to include means objectives. At the operating company level, environmental policies are often more detailed. They may also address basic objectives and they usually address means objectives and implementing policies.

In practice, corporate-level policy statements often include a mixture of objectives, strategies, and policies. Thus, one should expect pollution prevention to be addressed, at a minimum, as part of a corporation's broad environmental vision. If the corporate environmental statement includes means objectives and strategies as well, they should define what is to be done, when it is to done, who should do it, and how it should be done. Broad policies for guiding decision making may also be included.

At the operating company level, policy should be more specific and address means objectives as well as policies and programs. Since each of the companies studied involves an operating company within a large corporation, corporate-level environmental policies[9] as well as company-specific pollution prevention policies will be reviewed.

5.2.1 Corporate Environmental Policies

The pollution prevention policies at each of the four companies are based on a combination of corporate-level policies and company-level policies. Corporate-level

[8]How much policy discretion is exercised at lower levels of the organization depends on a number of factors: the distribution of power and authority, the degree of centralization, the organizational structure, the degree business units are related, the way resources are allocated, etc.

[9]The term "policies" is used broadly here to mean the written statements of corporate objectives, strategies, and policies that are generically called policies.

pollution prevention policies are examined for each company in Section 5.2.1. Company-level policies are examined in Section 5.2.2.

Since none of the corporations have stand-alone pollution prevention policies, the broader environmental policies at Lockheed Corporation (LC), McDonnell Douglas Corporation (MDC), and United Technologies Corporation (UTC) are reviewed. Table 5.2 provides an overview of the areas that will be in each corporation's environmental policy.

Evaluation Areas for Pollution Prevention	**LC**	**MDC**	**UTC**
Objectives			
Basic Objectives			
Products & Markets	No	No	No
Financial	No	No	No
Social	Yes	Yes	Yes
Means Objectives			
Market Position	No	No	No
Resources	No	No	No
Internal and External Relationships	Yes	Yes	Yes
Length (pages)	4	1	42

Table 5.2. Comparison of Corporate Pollution Prevention Policies

The policies contain both basic and means objectives and all define pollution prevention in terms of a basic social objective. The Lockheed Corporation and McDonnell Douglas Corporation environmental policies mainly address the basic environmental objectives. The United Technologies' policy, on the other hand, addresses basic objectives and a full range of means objectives and procedures. The great difference in the lengths of the policies is indicative of the difference in the level of detail that the UTC policy contains on means objectives and procedures. The specific policies of each corporation are presented below.

5.2.1.1 Lockheed Corporation

Lockheed's environmental policy is contained in Corporate Management Policy Statement (CMPS) Number 173, "Environmental, Safety, and Health Protection."

> It is the policy of Lockheed Corporation to be a good neighbor, employer, and corporate citizen by managing all phases of our operations to minimize adverse effects on the environment and the safety and health of our employees, customers, and communities surrounding our plants. It is also the policy of Lockheed Corporation to comply with applicable federal, state, and local laws and regulations related to the environment, safety, and health.
>
> The management of each company is responsible for managing its operations to assure compliance. . .[10]

The complete policy is four pages long. In addition to the basic policy quoted above, the policy assigns primary corporate-level environmental policy responsibilities to the Vice-President - Operations, who has the responsibility to:

> Develop and support a corporate pollution prevention program to assist the operating companies in the design and implementation of company waste minimization programs. Establish waste minimization goals and objectives for the Corporation.[11]

In addition, the policy lists specific responsibilities of the operating company presidents. These requirements include: using only Lockheed-approved hazardous waste contractors; reporting semi-annually on environmental, safety, and health programs to the chief operating officer; and ensuring training programs, record keeping, and staffing level are adequate.

The policy provides broad environmental guidance, and includes basic and means objectives, strategies, and policies. Environmental compliance is defined as the primary basic objective and it is framed in social terms. Being a good neighbor, employer and corporate citizen are secondary social objectives, but no guidance is provided to define

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[10]R. A. Fuller, Vice Chairman of the Board and Chief Operating Officer. "Environmental, Safety, and Health Protection," Management Policy Statement Number 173, (Calabasas, CA: Lockheed Corporation, 13 November 1989), 1.

[11]Ibid., 3.

what this means. Pollution prevention is addressed as a means objective for minimizing waste within the social objective framework. Operating company presidents are identified as the responsible managers. While the policy as written could support a strong central staff, this is not the case in practice. Most environmental issues have been delegated to the operating companies.

5.2.1.2 McDonnell Douglas Corporation

McDonnell Douglas Corporation's (MDC) corporate-level environmental policy is contained within a one-page occupational safety, health, and environmental quality statement:

> It is the policy of McDonnell Douglas Corporation to conduct it business in a socially responsible manner designed to provide safe and healthful operations for its employees, its customers, and the public, to assure compliance with environmental requirements, and to preserve company assets. . .[12]

The policy statement also specifically calls for each corporate component to, "adopt its own guidelines where laws or regulations may not provide adequate protection," to "evaluate potential health and environmental impacts when selecting and using hazardous materials," to "minimize emissions, effluents, and wastes," and to "integrate occupational safety, health, and environmental practices and requirements into design, test, and manufacturing." In addition, the policy states that, "Component management will provide leadership and support," and that, "it is the responsibility of every employee," to assist management in achieving compliance with the policy.

The MDC policy addresses social responsibility as the basic objective and it includes a number of strategies for achieving the objective (adopt guidelines; evaluate hazardous materials; integrate into design, test, and manufacturing; and minimize emissions). The

[12]McDonnell Douglas Corporation, "Policy -- Occupational Safety, Health & Environmental Quality." (St. Louis, MO: McDonnell Douglas Corporation, 3 August 1993).

policy does not specifically spell out source reduction or pollution prevention as preferred alternatives for meeting the basic objectives.

5.2.1.3 United Technologies Corporation

United Technologies Corporation's (UTC) environmental policy and policy principles, together with UTC Human and Natural Resource Protection (HNRP) Standard Practice (SP) 001, are the key implementing documents governing environmental activities in the corporation. The UTC policy is presented in an integrated occupational safety, health, and environmental statement:

> Policy: It is the policy of United Technologies Corporation to provide its employees with a work place safe from recognized hazards and to protect the natural environment. . .
>
> Safe working conditions and environmental protection are integral components of our business strategy. Therefore, management at all levels is responsible for identifying and attaining goals within each organization to ensure implementation of this policy. . .
>
> Each employee plays an important role by following established procedures and recommending improved practices where appropriate.
>
> In furtherance of this policy: Operating unit management accountable for meeting the business plan is responsible for developing and implementing management systems to ensure adherence to this policy. . .
>
> Corporate management will report to the Board of Directors of the Corporation, at least once per quarter, the status of the operating units with respect to compliance with this policy.[13]

SP-001, which contains the policy, policy principles, implementing guidance, and corporate performance goals is 42 pages long. This makes the UTC environmental policy statement the most extensive among the corporate-level policies studied.

In addition to the policy paragraphs, the SP-001 also contains fourteen policy principles on the topics listed below:

[13]Bob Daniell, George David and Art Wagner, "Human and Natural Resource Protection Policy," (Hartford, CT: United Technologies Corporation, 2 August 1993), 2.

1. Accountability
2. Organization
3. Property Transactions
4. Environmental Management
5. Industrial Hygiene Management
6. Safety Management
7. Annual Planning & Process Reviews
8. Communications
9. Education and Training
10. Comprehensive Evaluations
11. Hazardous Materials
12. Accident Investigations
13. Emergency Response Planning
14. Facility & Equipment Maintenance

Of the fourteen principles, three specifically address pollution prevention: 4) environmental management, 7) annual planning & process reviews, and 11) hazardous materials. The other principles address other good environmental management practices. Together, they form the basis for a strong corporate environmental policy ethic that supports pollution prevention.

One of the issues the environmental management principle addresses is waste reduction. This part of the principle requires periodic reviews of operations, maintenance, and purchasing practices; and consideration of waste reduction opportunities during pre-design reviews of new manufacturing and maintenance operations and processes. The annual planning and process review policy principle requires a safety and environmental review prior to the introduction of new materials and processes. The hazardous materials policy principle requires the operating companies to develop procedures that will promote the use of non-hazardous materials. If hazardous materials are used, procedures to minimize and control use and to reduce potential health, safety, and environmental risks are required.

UTC's environmental policy statement contains basic objectives, means objectives, strategies, and policies. The basic environmental objective (to protect the safety and health of employees, the environment, and the communities in which we operate) is stated as a social objective. The means objectives address providing sufficient organizational resources, but no connection is made with specific strategies or goals. The means objectives also address relationships with the internal and external organizational environment. Source reduction and pollution prevention are not framed as objectives for

reducing corporation expenditures on environmental compliance activities. Customer environmental issues and markets are not addressed.

In addition, UTC is the only corporation among those studied that has issued a public environmental, health, and safety progress report. The corporation plans to issue the reports annually. The first report was issued in 1993 and it discusses corporate environmental policy, accomplishments, and progress in meeting its environmental, health, and safety goals.[14] In addition, its lists the Federal and state environmental violations that have resulted in fines.

Finally, no copies of UTC's corporate environmental policy were available on site during the author's visit to P&W's Government Engines and Space Propulsion (GESP) unit. The GESP staff was familiar with UTC's corporate-wide pollution prevention goals and with P&W's company policy. This was surprising given UTC's efforts[15] to improve its environmental performance over the past several years.

5.2.1.4 Corporate-Level Pollution Prevention Goals

All three corporations have goals that address reducing hazardous waste generation and all three are voluntary participants in EPA's 33/50 Program (data on the EPA 33/50 Program for each of the four companies studied is presented in Section 5.2.3). In addition, UTC has also mandated reducing toxic air emissions. A summary of each corporations' goals is presented in Table 5.3.

5.2.2 Company-Level Pollution Prevention Programs

Within the overall policy framework established by corporate-level environmental policies, each company has developed more detailed policies to address pollution prevention at the company-level. Before describing the individual company policies, a set

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[14]United Technologies Corporation, "United Technologies Environment, Health, and Safety Progress Report," (Hartford, CT: United Technologies Corporation, 1993).

[15]UTC's problems and efforts to resolve them are discussed in Section 5.5.3.

of criteria for evaluating the policies is presented. Then, the company-level pollution prevention policies are described in the next four sections.

Goal Area	LC	MDC	UTC
Hazardous Waste Generation	Yes	Yes	Yes
EPA 33/50 Program	Yes	Yes	Yes
Toxic Air Emissions	No	No	Yes

Table 5.3. Corporate Pollution Prevention Goals

Terry Foecke, a leader in developing pollution prevention implementing strategies, states that a pollution prevention program[16] policy statement should provide a clear understanding of, 1) why a pollution prevention program is being implemented, 2) what will be done, and 3) who will do it.[17]

These criteria are used to evaluate the pollution prevention program policies at each company. A summary of the results is shown in Table 5.4. A "yes" in the table indicates that the company policy meets the criterion. Note that the policies at MDA-A and P&W do not meet all of the criteria.

Evaluation Areas for Pollution Prevention	LASC	LFWC	MDA-E	P&W
Foecke's Criteria for a Pollution Prevention Program				
Why is the program being implemented?	Yes	Yes	Yes	No
What will be done?	Yes	Yes	No	Yes
Who will do it?	Yes	Yes	No	Yes

Table 5.4. Comparison of Company-Level Pollution Prevention Programs

[16]A program includes specific activities and strategies, defines responsibilities, and addresses resources. In the companies studied, some pollution prevention initiatives are defined at the corporate level, but comprehensive pollution prevention programs are defined at company level.

[17]Terry Foecke and Al Innes, Minnesota Guide to Pollution Prevention Planning, (St. Paul, MN: Minnesota Office of Waste Management, 1992) 2-1.

5.2.2.1 Lockheed Aeronautical Systems Company

LASC's key pollution prevention policy statements are contained in two LASC Management Directives: A-60, "Environmental Protection" and S-19, "Hazardous Materials Review Board."[18]

According to Management Directive A-60, "Environmental Protection", LASC's core environmental policy document, pollution prevention is identified as a key part the company's environmental management philosophy:

> Objective: To assure that all Lockheed Aeronautical Systems Company (LASC) operations are conducted in compliance with the applicable environmental laws and regulations.
>
> Policy: To be a good environmental neighbor by controlling operations in a manner that eliminates or minimizes adverse effects on the environment while complying with the applicable laws and rules. . .
>
> Pollution Prevention: It is the policy of LASC to have a pollution prevention program for the minimization of hazardous wastes. Hazardous waste minimization involves volume or toxicity reduction through either a source reduction or recycling technique and results in the reduction of risks to human health and the environment. The pollution prevention program results in reduced costs and future liability, and ensures regulatory compliance. A Pollution Prevention Plan is maintained by the LASC Environmental Coordinator and provides documentation of the program activities and accomplishments.[19]

LASC Management Directive A-60 meets all three of Foecke's criteria for a hazardous waste minimization program. First, the program is being implemented to reduce costs and future liability.[20] Second, the purpose of the pollution prevention program is to minimize hazardous waste, and third, the policy tasks the Environmental

[18]Related documents include: Management Policy Statement No. 169, Occupational Safety and Health; Management Policy Statement No. 173, Environmental Protection; Corporate Operations Directive 17, Environmental Manual; Management Directive A-6, Disaster Prevention and Recovery; Management Directive A-57, Safety Program; Management Directive A-59, Occupational Safety and Health; and Management Directive S-12, Control of Hazardous Materials.

[19]Lockheed Aeronautical Systems Company, "Environmental Protection," Management Directive A-60, (Marietta, GA: Lockheed Aeronautical Systems Company, 29 June 1991), 1-2.

[20]Note that reducing cost and liability may be conflicting objectives.

Coordinator to maintain a Pollution Prevention Plan. Thus, the policy meets the criteria, but only for a very limited subset of possible pollution prevention objectives.

The policy focuses on manufacturing and does not address the product life cycle. This seems to minimize the role of the engineering design and product support functions. It does not task line managers. Instead, responsibility is assigned to the environmental management function. Finally, it is too specifically focused on hazardous waste minimization. Since air emissions, wastewater, stormwater, spills, housekeeping, etc. are not mentioned, there is a question as to whether these other areas are included in LASC's pollution prevention efforts. Finally, as it is written, the directive would seem to have little application to a new system other than hazardous waste minimization during production.

In addition to Management Direction A-60, LASC has two more narrowly focused directives that impact key portions of the company's pollution prevention efforts: Management Directives S-12, "Control of Hazardous Materials" and S-19, "Hazardous Materials Review Board." Management Directive S-12 covers day-to-day operating procedures for the acquisition, movement, storage, and disposal of hazardous materials. Management Directive S-19 establishes a Hazardous Materials Review Board (HMRB). The HMRB is, "Responsible for reviewing all hazardous materials currently located and/or in use at LASC and for approving the first-time acquisition of all hazardous materials in the future.[21]" Reviews for new materials must be conducted prior to the hazardous material being brought onto LASC property. Management Directive S-19 establishes the HMRB's responsibilities and membership, and the operating procedures for submitting materials for HMRB review.

The impacts on LASC's activities from these latter two management directives is much more evident than the impact from S-60. Management Directives S-12 and S-19

[21]Lockheed Aeronautical Systems Company, "Hazardous Materials Review Board," Management Directive S-19, (Marietta, GA: Lockheed Aeronautical Systems Company, 30 November 1991), 1.

establish well defined company-wide programs and procedures that meet all of the key policy criteria. Management Directive S-60, on the other hand, requires a pollution prevention plan be developed by the environmental staff. This is a very weak set of guidance and as one might expect, it has produced less concrete achievements.

5.2.2.2 Lockheed Fort Worth Company

LFWC's Environmental Resource Management (ERM) effort has benefited from the company's former status as a division of General Dynamics:

> The ERM Program began when a General Dynamics (GD) corporate team was chartered with the task of assessing the impact of future environmental trends on the aerospace industry. Among the team's projections were (1) an exponential increase in hazardous waste disposal costs, (2) a dramatic reduction in disposal alternatives, and (3) an ever increasing long-term liability associated with disposal of hazardous waste.
>
> Driven by these three findings, a corporate policy was established to reduce or eliminate the use of hazardous materials and the generation, discharge, and disposal of hazardous waste. The vision and ultimate goal was to achieve "Zero Discharge" of hazardous waste and emissions. This policy was implemented in 1985 because, according to GD's then Chairman and CEO Stanley Pace, "it makes good business sense."[22]

To support the pollution prevention portions of its Environmental Resource Management (ERM) program, LFWC has issued a number of policy documents. Among the companies visited, LFWC had the most well developed set of company-level environmental policies, procedures, and goals.

Standard Practice (SP) 10-52, "Hazardous Material Control & Elimination" addresses many aspects of pollution prevention. The SP states that LFWC

> . . . plans to ban, eliminate or reduce the use of hazardous materials. These materials are listed in Attachment A, Hazardous Material Elimination List. Organizations are required to use this list as a reference at the outset in the planning

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[22]Kevin R. McKee and Stephen P. Evanoff, "Environmental Resource Management at Lockheed Fort Worth Company (1984-1993)," in Proceeding of the Fifth Annual Environmental Management and Technology Conference/Southwest, held at Dallas, TX, 28-30 September 1993, (Glen Ellyn, IL: Advanstar Expositions, 1993), 179.

> phase of any task that may involve the acquisition or use of chemicals or hazardous materials. The goal is to eliminate hazardous materials at the very beginning in the design of products and facilities, in the selection of materials and equipment, and in the development of operating procedures.[23]

To implement this policy, SP 10-52 establishes a Hazardous Materials Management Program Office (HMMPO). The HMMPO operates like an integrated product team (IPT) in implementing pollution prevention at LFWC.

SP 10-52 meets all three of Foecke's criteria. First, the program is being implemented to eliminate hazardous materials and the resulting liabilities, wastes and emissions. Second, the purpose of the pollution prevention program is to eliminate hazardous materials at the very beginning in the design of products and facilities, in the selection of materials and equipment, and in the development of operating procedures. Finally, the policy tasks the Hazardous Materials Management Program Office (HMMPO) to implement a program to ensure progressive elimination of hazardous materials and tasks affected departments to comply.

The policy is the strongest seen at the four companies visited, but it could be strengthened. The Environmental Resource Management (ERM) office has adopted a number of general principles and specific goals. These principles are not included in LFWC's written policies, but they address a number of policy issues.[24] For example, ERM has adopted the slogan, "ERM is Everybody's Business." This concept is not expressed in LFWC's pollution prevention policy. In addition, ERM continues to use the strategic "Zero Discharge" goal developed while it was a part of General Dynamics: "Zero Discharge of hazardous materials to the environment is the vision and long-term goal of the Lockheed Fort Worth Company. . ."[25] Again, this concept is not explicitly stated in

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[23]Gordon England, President, Lockheed Fort Worth Company, "Hazardous Material Control & Elimination," Standard Practice 10-52, (Fort Worth, TX: Lockheed Fort Worth Company, 3 March 1993), 1.

[24]Since the principles are not included in the company's policy, they are only mentioned here. The principles are presented in Section 5.3.3 in describing LFWC's pollution prevention methodology.

[25]Mckee and Evanoff, 179.

LFWC's written policy. At General Dynamics (GD), this goal was part of GD's written corporate environmental policy statement. This is no longer the case at Lockheed. Finally, the policy does not specifically address the product life cycle. While design and operations are mentioned, the policy does not address LFWC's product support functions.

5.2.2.3 McDonnell Douglas Aerospace - East

MDA-E's General Operations Procedure (GOP) 2:16 is the company's primary occupational safety, health, and environmental quality standard. The core policy statement in the GOP is a restatement of the corporate policy. Following the restatement, the policy establishes three committees and assigns responsibility for environmental compliance at remote sites to the Facilities Manager. The policy also states that adequate resources will be provided; that safety, health, and environmental objectives will be included in the operating plan; and that MDA management is responsible for conducting operations in support of these objectives.

Evaluating MDA-E's policy using Foecke's criteria, the general operations procedure (GOP) fails to describe what will be done to operationalize the strategies in the corporate policy, and fails to assign specific responsibilities except for compliance at remote sites. As currently written, the GOP adds little to the corporate policy.

5.2.2.4 Pratt & Whitney

A P&W standard on pollution prevention establishes company policy along with a minimum framework for developing management systems at each facility including site-specific policies and procedures. The company policy on pollution prevention states:

> Pratt & Whitney will meet all federal, state, and local requirements associated with pollution prevention by creating and maintaining a system. The goal of the system is to prevent the generation of waste.[26]

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[26]Pratt & Whitney, "Pollution Prevention Management System," Environment, Health, and Safety Group Standard Number 1.0, (East Hartford, CT: Pratt & Whitney, 15 December 1992), 1.

To achieve the desired management system at each site, the standard sets minimum requirements in three broad areas: 1) identifying, quantifying, and tracking all hazardous materials and wastes, 2) developing and maintaining pollution prevention plans, and 3) ensuring all process changes and new processes are reviewed for environmental impacts as early in the planning stages as possible. Pollution prevention training is included as an optional component. UTC & P&W pollution prevention goals are listed in the standard's appendix. Table 5.5 lists the current UTC and P&W pollution prevention goals.[27]

Goal	**UTC**	**P&W**
Base Year	1988	1988
Target Year	1995	1995
% Toxic Air Reduction	50	85
% Process Hazardous Waste Reduction	50	80
% Reduction in EPA 33/50 Program 17 Chemicals	50	50

Table 5.5. United Technologies Corporation and
Pratt & Whitney Environmental Goals

The P&W standard tasks operating units to implement several strategies, but includes no clear objective. In addition, is fails to describe why the program is being implemented and who is responsible for implementation. The policy paragraph of the standard, which is quoted above, is so general and vague that it is nearly meaningless.

In addition to its pollution prevention management policy, P&W also has a policy on reducing the use of volatile halogenated chemicals. The policy requires eliminating the use of all volatile halogenated chemicals from facility and product operations and it establishes target dates for different classes of chemicals. Volatile halogenated chemicals are defined to be any volatile organic chemical that contains one of more of the halogens: fluorine, chlorine, or bromine. Unlike the pollution prevention policy, this policy includes clear

[27]None of the other companies include specific goals in their policies.

objectives, meets all of Foecke's criteria, and provides useful guidance for decision making.

5.2.3 Company-Level Toxic Release Inventory Reports

All of the companies studied participate in EPA's 33/50 Program and the program's goals for reducing the releases of seventeen chemicals are a key part of the quantitative goals for the company. Table 5.6 shows a comparison of each company's progress in reducing its releases of toxic release inventory (TRI) chemicals. The data shown use 1988 as the baseline year and include data through 1992. The EPA 33/50 Program addresses seventeen chemicals from the TRI report. Overall, the TRI reports cover reportable releases on more than 200 different chemicals.

Company	% Reduction EPA 33/50 Program	% Reduction All TRI Chemicals	Number of Different TRI Chemicals Reported in 1992	Total 1992 TRI Releases (Pounds)	Ratio of Total 1992 TRI Releases to Total Sales (Pounds/$)
LASC	76%	72%	13	1,020,800	≈0.00034
LFWC	64%	76%	16	941,400	≈0.00013
MDA-E	4%	12%	18	709,027	≈0.00010
P&W (GESP)	41%	54%	3	57,578	Not Applicable

Table 5.6. Company-Level Toxic Release Inventory Data for 1988 to 1992

The data in Table 5.6 show that LASC, LFWC, and P&W have already achieved the 33% reduction called for by 1993 in the 33/50 Program. In addition, LASC and LFWC have already achieved the 50% reduction called for by 1995. Most of the reductions at LASC and LFWC can be attributed to reductions in solvent releases. At P&W, reductions in solvent and ammonia releases contribute to the progress that has been made. Additional information on each company's TRI releases is included in the case studies.

Another way to compare the TRI data is to look at the ratio of a company's 1992 releases to its 1992 sales. Looking at the three airframe companies[28] (LASC, LFWC, and MDA-E), which involve roughly comparable manufacturing operations, LFWC and MDA-E each had total sales of approximately $7 billion in 1992. LASC's total sales for 1992 were less than half of those for the other two companies (Lockheed's 1992 sales for its entire aeronautical group were only $3 billion). While this comparison is not precise because the products are different at each company and financial data for LASC is not separately reported, it illustrates that LASC releases approximately twice as many pounds of TRI chemicals per dollar of sales when compared with LFWC and MDA-E. The ratio also shows that MDA-E releases that lowest amount of TRI chemicals per dollar of sales. Based on this fact, one should expect reductions to be more difficult to achieve at MDA-E.

5.2.4 Summary of Pollution Prevention Objectives, Strategies, and Policies

Each corporation and operating company in the study has a written environmental policy that addresses at least some aspects of pollution prevention. All of the policies frame pollution prevention as a basic social objective and none include pollution prevention in financial or profitability basic objectives. When resources are addressed in the policies, it is usually a requirement for adequate budgeting for environmental compliance requirements and supporting activities.

In looking at the means objectives in the policies, none of the policies address markets. The P&W policy is the only policy that uses the word "product," but it is used in terms of designing out P&W manufacturing problems, not in terms of improving sales or

[28]P&W's GESP operation is a research and development facility. Manufacturing is done at other locations. Because of this difference and the fact that P&W's products are so different from the other companies, this ratio is not applicable when looking at the airframe makers.

meeting customer environmental requirements. In addition, none of the policies include pollution prevention as a means of conserving resources as is done at 3M.

In summary, all of the units studied have policies requiring pollution prevention practices be implemented, but the implementation details vary greatly in terms of what is to be done, who is to do it, and how it should be done. On the other hand, the policies all included very similar social responsibility logic explaining why pollution prevention should be done. Finally, the corporations have all adopted the EPA's 33/50 Program goals as a centerpiece in their programs. This provides powerful evidence that EPA leadership, or lack of leadership, in setting the national pollution prevention agenda is a critical element in moving US industry toward source reduction.

5.3 Pollution Prevention Paradigms

Three pollution prevention paradigms are identified in this research, but before describing them, a short discussion on how the term "paradigm" is being used will be presented. Following this, an overview of the paradigms will be presented, and then, each paradigm will be described in a separate subsection.

According to Allison, "A paradigm is a systematic statement of the basic assumptions, concepts, and propositions employed by a school of analysis."[29] In this study of pollution prevention paradigms, the basic assumptions, concepts, and propositions will be described by presenting four components of each paradigm: 1) the basic unit of analysis, 2) the process used for analysis, 3) organizing concepts, and 4) general propositions. The components will be described for each paradigm in the separate subsections that follow the paradigm overview.

Three distinct pollution prevention paradigms were identified in the case studies each defined by their starting point for approaching pollution prevention: 1) the waste-

[29]Graham T. Allison, Essence of Decision (Boston: Little, Brown, and Company, 1971), 32, citing Robert Merton, Social Theory and Social Structures (New York: Free Press, 1967), 69-72.

reduction paradigm, 2) the design materials paradigm, and 3) the compliance paradigm. Given their different starting points, each has a different impact on the pollution prevention opportunities identified and on the results achieved. The waste-reduction paradigm starts with setting goals for reducing existing waste streams, the design-materials paradigm starts with identifying hazardous materials during design, and the compliance paradigm starts with compliance with the environmental regulations. The three observed paradigms are listed below together with their starting points:

	Paradigm	Starting Point
1.	Waste-reduction	Waste streams
2.	Design-materials	Design materials
3.	Compliance	Compliance regulations

The relationship among the starting points of the paradigms can be seen in the product life cycle illustration shown in Figure 5.2 where the starting points are represented by the highlighted numerals.

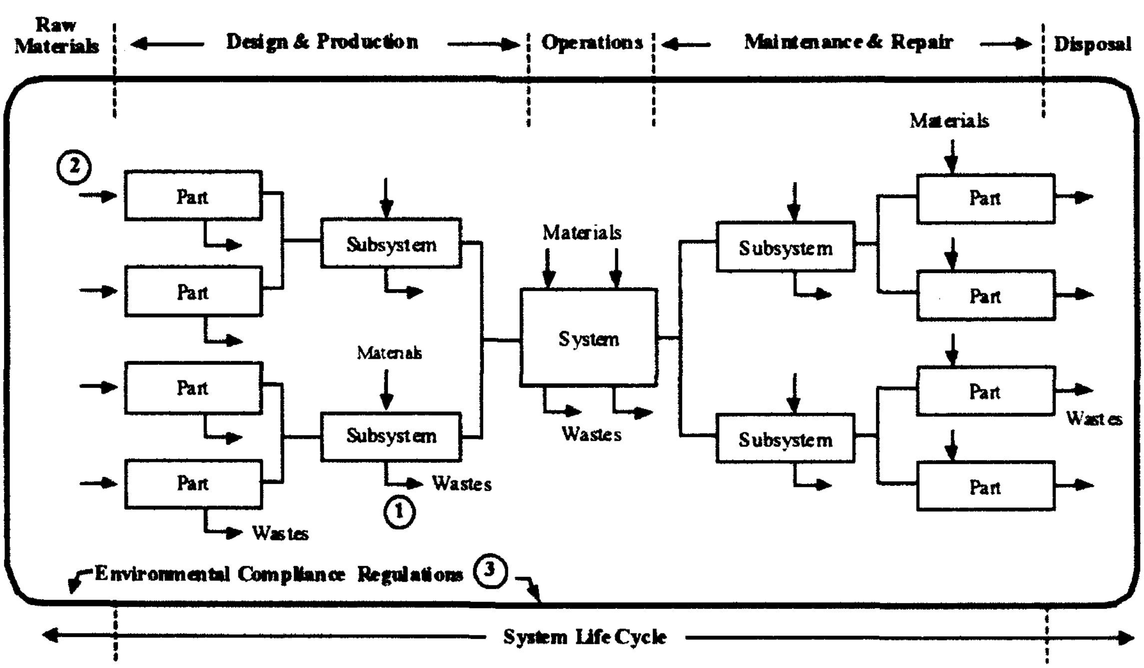

Figure 5.2. Pollution Prevention Paradigms in the Manufacturing/Use Life Cycle

The life cycle stages of materials in manufacturing and product use are shown at the top of the figure and the border around the process represents the constraints on the system that result from environmental regulations. Within the border, the relationships among raw materials, parts, subsystems, and the complete system are shown.

The significance of the different paradigms is that they result in different pollution prevention activities. In thinking about pollution prevention, many questions can be asked: What is important? Who is responsible? What are the alternatives? The answers to these questions are influenced by the implicit conceptual paradigm being used. For example, asking what is important in the waste-reduction paradigm is likely to produce a prioritized listing of waste streams. Asking what is important in the compliance paradigm may produce a listing of new compliance requirements prioritized by effective date of the regulations and by the cost for getting into compliance; existing waste streams that are in compliance, even if they are very large, will usually be excluded from the analysis because of the procedures followed in performing the analysis.

Similarly, different functional areas of a company will be responsible for implementation of different paradigms, and different alternatives will often be generated for preventing pollution in the different paradigms. Because the paradigms will frequently produce different results and are implemented in different ways, it is important to understand the assumptions and procedures used in each.

In describing each paradigm, the procedures used at one company will be highlighted. The procedures presented should be understood to represent one possible variant or application of the paradigm. Note that by simplifying the processes into relatively simple logic diagrams some of the analytical activities that are part of the process are lost; and also that none of the companies proceed exclusively using only one framework for analysis. Each does appear to predominantly employ one paradigm, but

occasionally shifts from one variant to another and sometimes from one paradigm to another to solve a specific problem or to satisfy a particular requirement.[30]

In the companies studied, more than one paradigm was observed within each company. Multiple paradigms were often observed within the environmental management functional area. In addition, different functional areas within each company often employ different paradigms. Table 5.7 shows where the paradigms are being used within some of the functional areas of each company that are described later in the paper.[31] The "+" marks indicate the relative strength of the paradigm within the company, so that a paradigm shown with a "++" has more staff time devoted to its implementation than a paradigm with a "+". The "+++" indicates the dominant paradigm within the company.

Company	Paradigm 1 Waste reduction	Paradigm 2 Design Materials	Paradigm 3 Compliance
LASC			
Environmental Management	++	+++	+
F-22 Program		+++	
LFWC			
Environmental Resources Management	+++		+
Hazardous Materials Mgmt. Program Office	+++		+
MDA-E			
Environmental Management	++		+
Environmental Assurance			+++
P&W			
Environmental Management	+++		+
Design Metallurgy		+	

Table 5.7. Application of Pollution Prevention Paradigms

In Table 5.7, all four companies are shown with either a "++" or "+++" indicator for the waste-reduction paradigm. This paradigm includes pollution prevention efforts such

[30]Allison, 8. Allison also found few analysts proceed exclusively and single-mindedly in terms of only one of his conceptual models.

[31]The organization structures and the roles of the functional areas mentioned here are described in detail in Section 5.4.1.

as the EPA 33/50 Program. In each case, the parent corporation has "signed-on" to the program and implementation has been assigned to the environmental management functional area. This commitment to the EPA 33/50 Program, to hazardous waste minimization, and to similar efforts is reflected in the table by the relative strength indicated for the waste-reduction paradigm. While the waste-reduction paradigm is being used at each company, it is not the dominant paradigm at two of the four companies studied. In order to better understand the relationships illustrated in Figure 5.2 and in Table 5.7, each paradigm is described below.

5.3.1 Waste-Reduction Paradigm

The waste-reduction paradigm is based on the waste minimization concept. The concept's objective is to reduce the amount and toxicity of wastes that are produced. This is accomplished using procedures that focus on identifying waste streams, setting goals for reduction, and evaluating alternatives for reaching the reduction goals.

At LFWC, the procedures used to implement the waste-reduction paradigm are similar to the waste minimization assessment procedures recommended by the EPA.[32] Figure 5.3 shows the EPA waste minimization process along with the LFWC process. Both processes include a number of preliminary management steps that include recognizing the need to minimize waste and planning a waste minimization program. Both processes also include a goal setting step and feature a repeating assessment-analysis-implementation loop. The key difference between the processes is the management loop shown on the left side of the LFWC process. While the EPA process focuses on performing the technical assessment-analysis-implementation loop, the LFWC process, gives equal weight to program evaluation and goal setting.

[32]Hazardous Waste Engineering Research Laboratory, Waste Minimization Opportunity Assessment Manual, (Cincinnati, OH: US Environmental Protection Agency, July 1988), 4, EPA/625/7-88/003.

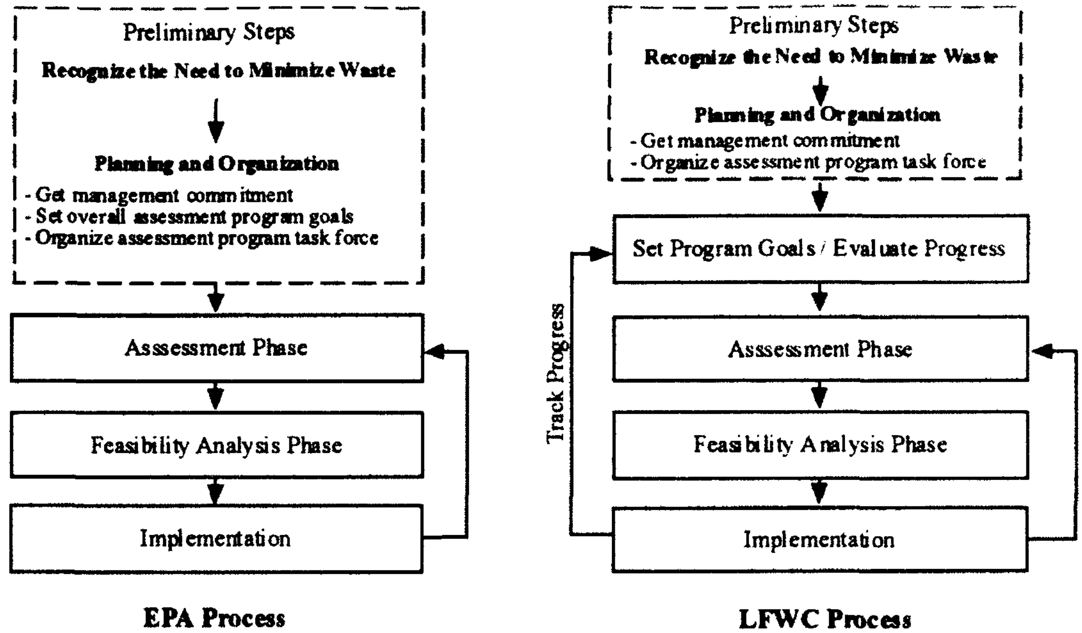

Figure 5.3. U.S. EPA & LFWC Waste Minimization Processes

The EPA process and the LFWC process are variants of the procedures used within the waste minimization approach to pollution prevention. The waste-reduction paradigm's components and characteristics are listed in Table 5.8.

A key feature of LFWC's waste minimization procedures is the extensive use of goals and metrics. The goal structure at LFWC ranges from general principles (a vision statement and philosophy) to specific quantitative targets. The general principles are used by LFWC's Environmental Resources Management (ERM) section in their employee education programs, but they are not part of the company's written policies.

At the top of the environmental goal structure is LFWC's Environmental Resources Management Vision:

> Zero impact to the environment is achieved through a caring partnership of employees, community, suppliers, and customers. We are the leader in ERM and minimize risk to our community and employees.[33]

[33]Stephen P. Evanoff, Manager, Environmental Resources Management, "Lockheed Fort Worth Company Environmental Resources Management (ERM)," presentation materials provided during interview by author, 27 October 1993, Forth Worth, TX.

Component	Characteristics
Unit of analysis	- Pollution prevention is achieved by minimizing wastes.
Process used for analysis	- Identify waste streams, set goals for reduction, assess alternatives for reduction, and implement changes (see Figure 5.3)
Organizing concepts	- Senior Management. Since the effort is goal oriented and often downward directed, a senior manager at the operating company and facility levels is usually held accountable for progress. - Environmental Management. Day-to-day program administration is usually delegated to environmental management since releases are often already tracked to meet permit requirements or for toxic release inventory (TRI) reporting. - Line Management. The degree of accountability assigned to line managers for meeting the goals varies widely. In the companies studied, accountability was jointly assigned to line management and to environmental management. At P&W, the accountability was roughly evenly split; at LFWC, environmental management had the greater share; and at LASC and MDA-E, relatively little responsibility was placed on line management. - Functional Staffs. Functional staffs such as health and safety, operations, engineering, purchasing, materials and processes, etc., participate in identifying and evaluating alternatives. They are typically integrated into the process using committees, boards, or teams.
General propositions	- The process is usually applied to existing waste streams and to existing manufacturing equipment and facilities. Since the process begins at the "end of the pipe" and works backwards, the activities furthest from the waste stream in the product life cycle receive the least amount of attention (usually product design, and research and development). In addition, the process often ignores post-manufacturing activities associated with customer use of the product and ultimate disposal (the activities shown on the right-hand side of Figure 5.2). - Goals are usually set arbitrarily by senior management.

Table 5.8. Characteristics of the Waste-Reduction Paradigm

Since zero impact to the environment is impossible to achieve, the vision statement cannot be taken as an operational goal. Instead, the vision statement can be understood as a statement (a social objective) of management commitment to environmental protection. Just below the ERM Vision in the hierarchy is the ERM Philosophy:

1. Pollution prevention and toxics use reduction are the foundation for our program and the focus of our projects.

2. Environmental administration and policy issues must be consolidated into a single function and must have top management support and visibility.
3. Environmental responsibility and knowledge for day-to-day operations must be driven to the working levels in all functions.
4. Given the proper training and tools, people will do the right thing!
5. We are a service organization; the manufacturing organizations and the USAF are our principal customers.[34]

Next in the hierarchy are the environmental program strategic goals:

1. Achieve zero discharge
2. Assure continued compliance
3. Maintain proactive communications
4. Develop a comprehensive hazardous materials management system
5. Implement risk management.[35]

#	Major Area	Metric
1.	Hazardous Waste	Tons
2.	Wastewater Contaminants	Pounds of Heavy Metals
3.	Air Emissions	Tons
4.	PCB Devises	Number of Devices
5.	Ozone Depleting Chemical Use	Tons
6.	Underground Tank Removal/Replacement	Number of Tanks
7.	EPA 33/50 Program Transfers	Tons
8.	TRI Report Transfers	Tons
9.	Non-Hazardous Industrial Solid Waste	Tons Disposed
10.	Non-Hazardous Industrial Solid Waste Recycling	Tons Recycled
11.	Annual Off-Site Disposal Facility Audits	Number of Facility Audits
12.	Chemical Spill Prevention Measures	Number of Measures
13.	Unresolved Notices of Violation	Number of Open Notices
14.	Air Force Environmental Audit Findings	Number of Open Findings
15.	Awareness / Information Tools	Number of New Tools
16.	Environmental Training	Number of People Trained

Table 5.9. LFWC Environmental Metrics

[34]Ibid.

[35]Ibid.

The last step in the hierarchy involves developing annual goals. This involves setting quantitative goals for targeted waste streams and qualitative goals in other areas. Examples of areas with qualitative goals and the metrics used to measure progress are shown in Table 5.9. To complete the management loop, which is shown in the LFWC process in Figure 5.3, the ERM staff tracks and evaluates these metrics monthly, quarterly, and annually.

Finally, tracking and evaluating the metrics is an internal LFWC activity. Even though the F-16 is the only product manufactured at the Fort Worth facility, none of LFWC's metrics are used by the Air Force to manage the F-16 program.

5.3.2 Design-Materials Paradigm

The design-materials paradigm focuses on hazardous materials as they are selected during the design process. As implemented at LASC, for example, the paradigm involves using a set of procedures that were developed for the F-22 Engineering and Manufacturing Development (EMD) program. In developing the procedures, LASC's objective was to:

> Ensure that hazardous material (HM) environmental, health and safety concerns are identified and controlled during EMD by the F-22 team (Lockheed, Boeing, General Dynamics), including its associate and subcontractors, in the design, manufacture, operation, repair, maintenance, support, and disposal phases over the weapon system life cycle.[36]

The procedures LASC uses in implementing the design-materials paradigm are shown in Figure 5.4.[37] The key steps in LASC's identification-evaluation process involve identifying hazardous materials early in the design process, evaluating the benefits, risks,

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[36] Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," (Wright-Patterson AFB, OH: Aeronautical Systems Center, 6 March 1992), 2-2, CDRL A001, DI-OT-90-34206, WBS 41A0.

[37] Arline Denny, "F-22 Hazardous Materials Program," presentation made at the 8th Annual Aerospace Material Management Conference, Chandler, AZ, 26-28 October 1993, (Marietta, GA: Lockheed Aeronautical Systems Company, 1993), 7.

and alternatives in a timely manner, and then making a balanced program decision that meets as many of the design requirements as possible. The final two steps in the process, documentation and risk acceptance, are accomplished using procedures spelled out in the F-22 contract.

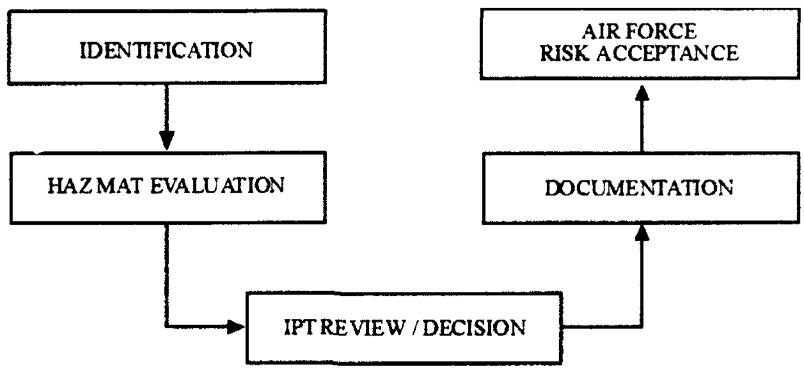

Figure 5.4. LASC Identification-Evaluation Process

The list of required documentation is contained in a hazardous materials data base and includes the information specified a Data Item Description.[38] LASC summarizes a material's risks to the Air Force for acceptance in a Material Hazard Action Record.[39]

[38]Data Item Description OT-90-34208 requires the following information:

1. Hazardous material or waste name
2. Usage
3. Material Safety Data Sheet (MSDS) numbers
4. Material Specification numbers
5. Chemical components
6. Quantity used
7. Hazards of material to personnel or environment
8. Expected exposure levels and established exposure limits
9. Maintenance and repair procedures and their related exposure limits
10. Recommended safety and handling procedures, including personnel protective equipment
11. Requirements for transportation of material
12. Requirements for storage of material
13. Recommended disposal procedures

[39]MHARs are to be prepared for material hazards that are significant enough to require special management attention. The MHAR describes the material hazard, the operation or conditions when the hazards occurs, the control measures implemented to control the hazard, and a chronological event log or the actions taken to control the hazard, analysis performed, review, and risk acceptance by the System Program Office (SPO).

The identification-evaluation process begins when a new material is proposed by an integrated product team (IPT) for use (identification) in the system. There are no specific goals for reduction or for the total number of materials to be used, although tracking the use of specific hazardous materials on a priority list, such as those targeted in the EPA's 33/50 Program, is easily accomplished. Success is defined in terms of completing the steps in the process for each hazardous material identified and adopted for use.

The strength or weakness of LASC's procedures rests on the criteria used in the evaluation step and on the requirements that constrain the decision step. At LASC, the evaluation step occurs in the Hazardous Materials Review Board (HMRB). The members of the HMRB are listed in Table 5.10.

Director of Safety and Environmental, Chairperson
F-22 Hazardous Materials Program Manager
Safety Operations Environmental Hazardous Materials Control Industrial Hygiene
Fire Protection
Materials and Process Engineering
Material Science and Testing
Medical Director
Facilities Operations Buildings and Utilities Maintenance
Operations Environmental Compliance Materials Management
Legal

Table 5.10. Hazardous Material Review Board Membership

The HMRB reviews each hazardous material and identifies the environmental compliance, health and safety requirements, determines the substitution potential for less

hazardous materials, and provides recommendations[40] to the integrated product teams (IPTs).[41] The HMRB review, as practiced at LASC, is a yes-or-no screen.[42] HMRB approval does not mean that the material will be used. That decision is made by the IPT. Hazardous materials that are not approved by the HMRB are usually rejected based on the material's intrinsic risks and the availability of a less hazardous substitute.

Responsibility for identifying that a new a hazardous material is being considered for use rests with the IPT that plans to specify the material. Once the IPT decides to propose a new material, one of the IPT's engineers starts the HMRB process by completing a three-page, hazardous material review submittal form.[43] Using the information submitted, technical data added by the environmental, health, and safety staff, and a material safety data sheet, the HMRB rates each material using a scoring model. An outline of the model's current components is shown in Table 5.11.

The model is used to calculate a degree of hazard for each material. Each factor in the model is scored using a defined set of criteria. For example, *if a material can be used* with no personal protective equipment, its score for the factor is "0." If contact protection measures such as gloves and face shields are needed, the material scores a "1"; if a respirator is needed, the material scores a "2"; and if fully self-contained full-body protection is needed the material scores a "3".

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[40]The review includes considering: health hazards, industrial hygiene and medical monitoring. toxicology, fire protection and flammability, reporting requirements, personnel protective equipment, environmental regulatory compliance, environmental emissions and controls, and disposal requirements.

[41]LASC, "F-22 Program Weapon System Hazardous Materials Program Plan," 3-5.

[42]When approving a material for use, the HMRB issues specific instructions that define personal protective equipment, ventilation, disposal, and other requirements for the specific application. Since each approval is specific for the specified process and location, each different use of a material must be approved.

[43]The form lists the requester, a description the material including what material if any the new material will replace, a description of what the material will be used for, quantities needed, processes involved, etc.

CATEGORY	SCALE
Health	
Personal Protective Equipment	0 to 3
Ventilation	0 to 3
Toxicology	0 to 10
Fire Protection	
Health	0 to 4
Flammability	0 to 4
Reactivity	0 to 4
Special Restrictions	0 or 4
Quantity Restrictions	
Volatile Organic Compound	0 or 4
Hazardous Air Pollutant	0 or 4
Ozone Depleting	0 or 4
Toxic Substances Control Act	0 or 4
Monitoring	
Industrial Hygiene	0 to 3
Medical	0 to 10
Disposal	0 to 3
Reporting	
Toxic Release Inventory	0, 4, or 8
Hazardous Waste	0 or 4
Toxic Substances Control Act	0 or 4

Table 5.11. Hazardous Material Scoring Model

If a material presents substantial risks, the IPT's engineer will be asked to explain to the HMRB why the material is needed, what trade-offs are involved, and what alternatives are being considered. This places the burden on the IPT to balance all material selection criteria and to be able to "explain" the IPT's preliminary decision. In the F-22 program, the HMRB has approved about 98 percent of the hazardous materials it reviews. Following HMRB review, the IPT makes a final decision on whether or not to use the material.

As observed during the site-visit, LASC's HMRB appears to be well organized and to operate efficiently. It includes mid-level managers as the decision makers. The HMRB operates formally and engineers proposing hazardous materials are often asked to defend the merits of their selection. A strength of the HMRB is that the proposer is forced to consider the company's pollution prevention policy, look at alternatives, and convince the HMRB that approving the material is the best solution. This puts the principal burden on

the designer to demonstrate that the material should be approved, rather than on the environmental, health, and safety staffs to prove that a material should be rejected. This is a key difference between the design-materials paradigm and the waste-reduction paradigm. In the waste-reduction paradigm, the design staff has little or no responsibility. Placing responsibility on designers creates a different organizational dynamic and culture for pollution prevention.

The other companies each have, or are working to establish, a review procedure for controlling the first time purchase of new materials, but the processes are paperwork coordination procedures that are related to purchasing actions, not to design. In these processes, a burden is placed on the environmental staff to "prove" that a material should not be used. Because these processes are not design oriented, they fit better into the waste-reduction paradigm than into the design-materials paradigm.

These differences between the design-materials paradigm and the waste-reduction paradigm are reflected in the components and characteristics of the design-materials paradigm that are listed in Table 5.12. Key characteristics of the design-materials paradigm that differentiate it from the waste-reduction paradigm are its focus on design materials and the responsibility and accountability that are assigned to the design staff.

A strength of the design-materials paradigm is that it incorporates environmental, health, and safety information into the design process for making decisions on materials during the design of a product.[44] The greatest weakness in applying this paradigm to systems acquisition is that it does not include a continuing systematic process for carrying out pollution prevention as the logistics support for the system is defined in detail. Normally, the process of specifying maintenance and repair tasks does not even begin until

[44]The portion of the system development process that most impacts materials selection begins during the demonstration-validation phase of the program and continues into engineering and manufacturing development (EMD) until the critical design review (CDR). At the CDR, the system's overall design and materials are established, leaving only final detailed design to be completed.

well after selection of a system's materials has been finalized at the critical design review (CDR). While logistics representatives on the IPTs provide input on logistics concepts during design, no details on quantities, frequencies, or locations of use for materials selected during design are available. This limits the effectiveness that life cycle cost and impact assessment methodologies can have during the evaluation phase of the paradigm.

Component	**Characteristics**
Unit of analysis	- Pollution prevention is achieved by designing products to minimize the environmental impacts associated with materials.
Process used for analysis	- Identify hazardous materials as early as possible during product design, evaluate alternatives, and select materials that meet product requirements (See Figure 5.4) - Material alternatives include using reused and recycled materials.
Organizing concepts	- Project Management. Accountability is usually assigned to the design manager. - Design Engineering. Material selection is an engineering responsibility. Since most engineers are not experts in environmental issues, an integrating process is needed to provide the technical information and advice needed on the environmental aspects of materials selection. - Environmental Management. Environmental specialists serve as "consultants" to the design process. If an integrating structure is not put in place, the effort will be ineffective. Alternatively, the design engineering function will develop its own environmental expertise. - Functional Staffs. The health and safety staffs must be integrated into the design process along with environmental management.
General propositions	- The design process inherently involves trading-off product performance, cost, and schedule requirements. The effectiveness of the paradigm rests heavily on clearly defining environment requirements. - This approach looks at the "front-end" of the product life cycle and works forward. The activities furthest from material selection in the product life cycle (waste treatment and disposal) receive the least amount of attention.

Table 5.12. Characteristics of the Design-Materials Paradigm

One method for helping to overcome this shortcoming is to amend the procedures being used to implement the paradigm. Prior to the contract award, the Air Force suggested a process-oriented approach for addressing the environmental issues that arise in the product life cycle after manufacturing.

> Too often an approach is used which compares lists of all regulated chemicals with lists of all materials associated with the system. Usually, this method results in unmanageably large numbers of potential hazards. . . In addition, significant health hazards can be overlooked if the material in question has not yet been identified as a regulated chemical. In contrast to the list-based approach, health and environmental professionals typically use a process-based approach. This process involves determining what major processes are performed, what materials are used in large quantities, and what wastes present disposal problems. . . This process-based approach makes it possible to focus limited resources on the most important hazardous materials issues first.[45]

Lockheed's Hazardous Materials Program Plan (HMPP), developed to meet the contract hazardous materials requirements, included just such an approach. The HMPP includes prioritization guidance for focusing the hazardous materials program on the most important materials. Priority materials were to be identified based on the following factors:

- Materials not common to standard aerospace manufacturing,
- Chemical production and use reduction goals established by regulation,
- Large quantity use,
- Severe use restrictions by environment, health and safety regulations, or
- Materials having significant hazardous material life cycle cost requirements.[46]

LASC does not use a priority list based on these factors because they have been supplied with a list by the Air Force (their customer). What is to be done once the materials are prioritized is not described in the HMPP.

This has not prevented LASC from successfully using the technique, however. LASC began by identifying the processes, specifications, and uses of the materials on the Air Force's priority list. Beyond this, they identified processes and specifications likely to contain hazardous materials that would be used during operation, maintenance, and repair.

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[45]Lt. Col. Harvey Clewell, remarks recorded in the, Advanced Tactical Fighter (ATF) Environmental and Hazardous Materials Control (EHMC) Working Group (EWG) Minutes, meeting held at Wright-Patterson AFB, OH, 17 October 1990, (Wright-Patterson AFB, OH: ASD/YFMG, 27 November 1990), 2.

[46]Ibid., 2-3.

These include materials such as adhesives, paints and coatings, sealants, cleaners, and lubricants and oils as well as processes such as plating, anodizing, conversion coating, etc. This is a key step. By looking at processes and materials known to cause environmental impacts in operations and maintenance, LASC broadened the scope of the identification step in their identification-evaluation process. Now, instead of the environmental staff passively reviewing hazardous materials proposed by the design engineers, they are in a position to explore alternatives and issue design recommendations before a hardware design or a maintenance procedure takes form.

These improvements are illustrated in LASC's current identification-evaluation process that is shown in Figure 5.5.

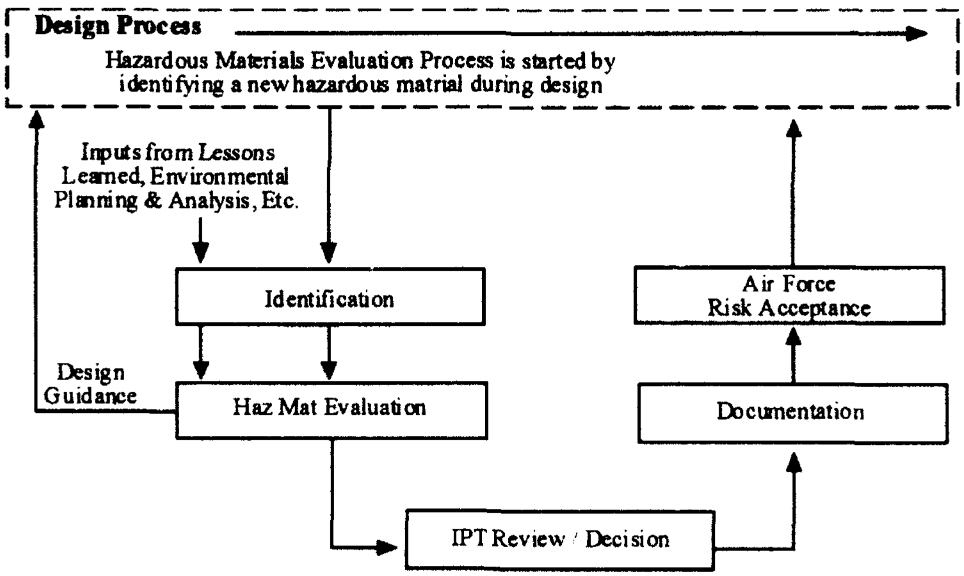

Figure 5.5. Revised Idenfitication-Evaluation Process

The revised process incorporates a review of priority materials, processes, and specifications, that is independent of the normal IPT-initiated review. The process as it was initially implemented is shown in Figure 5.4. In the revision, the evaluation process can be initiated outside the immediate design process. The goal of the revised process is to provide design guidance before hardware is designed, maintenance processes are

developed, or technical documentation is written. A remaining challenge is to define a systematic process for providing the additional input.

Unfortunately, since this revised process is not defined in the HMPP, there are no program resources allocated to new portions of the process and the work is being carried out informally. Formalizing the task and allocating sufficient resources has the potential to contribute significantly to the pollution prevention opportunities that will be discovered and implemented in the remaining seven years of the program's EMD phase.

5.3.3 Compliance Paradigm

The compliance paradigm achieves pollution prevention by using source reduction and recycling strategies to meet new environmental compliance requirements. Figure 3.3 illustrates the range of strategies that are included in source reduction and recycling. MDA-E, for example, implements the compliance paradigm using a strategic-planning process to define what must be done, why it must be done, when it must be done, and how much it will cost. At the end of a strategic-planning cycle, the completed plan describes the activities needed to implement environmentally compliant processes and to replace hazardous materials with acceptable alternatives over a six year planning horizon. The key elements of MDA-E's strategic-planning process are shown in Figure 5.6.[47]

The process starts with an analysis of environmental compliance regulations that MDA-E calls Directives Analysis. This analysis looks at compliance requirements and potential requirements for all MDA-E operating locations and details the required compliance dates, control limitations or other requirements, and assigns a maturity classification.

The maturity classification indicates the likelihood that each requirement will become a firm compliance requirement. The system assigns each requirement to one of

[47]Ron Aarns, "Environmental Assurance - Strategic Planning Process," discussion charts provided during interview by author, McDonnell Douglas Corporation, St. Louis, MO, 12 November 1993.

the five classifications shown in Table 5.13.[48] During development of their 1993 plan, 141 directives were identified and classified, with twenty assigned to Class 1 and seventeen assigned to Class 2. The remaining 104 directives were assigned to classes three, four, and five.

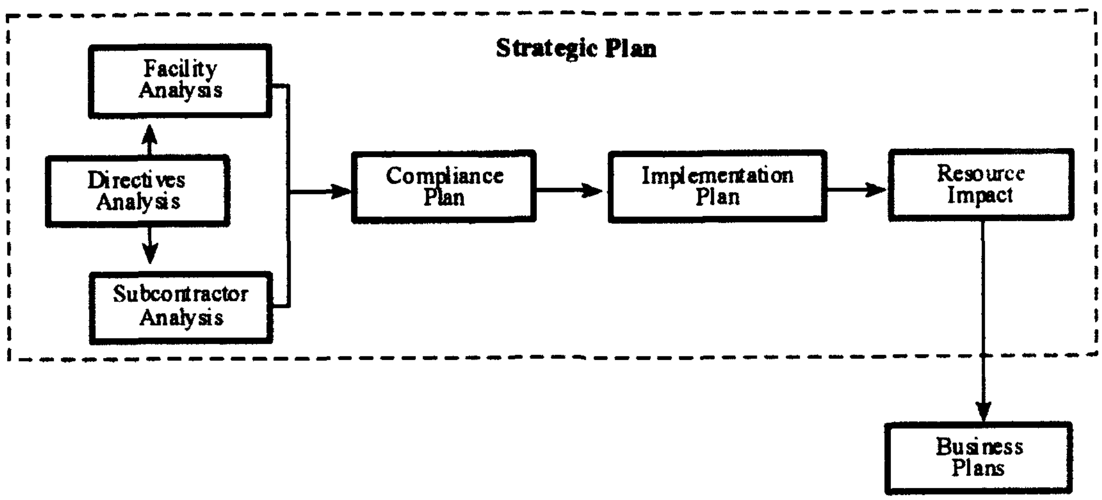

Figure 5.6. MDA-E Strategic-Planning Process

Armed with an itemized compliance requirements listing from the directives analysis, MDA-E's strategic planning process proceeds to the steps labeled Facility Analysis and Subcontractor Analysis in Figure 5.6. In the Facility Analysis, teams are assigned to evaluate each building to identify facilities and process equipment that will be impacted by the upcoming directives. The Facility Analysis looks at required changes over a six year planning period. The Subcontractor Analysis assesses the need to modify process and material specifications or contract terms to support MDA-E's strategic plan.

During the compliance planning portion of the process, the collective requirements on each facility and process are considered and "initiatives" are established that outline general courses of action that will meet the requirements. Once a comprehensive list of

[48]Ibid.

initiatives is completed, business cases are logically organized for addressing the initiatives. Each business case identifies the operation involved, the directives impacting the operation, describes the purpose of the operation, and evaluates alternate solutions based on probable production and quality impacts, and on risks, and costs. Then, specific solutions are analyzed to determine each solution's ability to meet the set of applicable requirements. In 1993, this process produced thirty-six initiatives that were assessed in twenty-two business cases.

Class 1	Documented directives with firm, specified control limitations and known compliance dates
Class 2	Unreleased directives, or expected revisions to existing directives, with scheduled release and compliance dates, near certain limitations, but not yet binding.
Class 3	Unreleased directives, or expected revisions to existing directives, with a scheduled release date, but evolving control limitations.
Class 4	Directives, or revisions to existing directives, under development with no scheduled release date.
Class 5	Speculation on potential future directives

Table 5.13. Directive Maturity Classification System

A qualitative risk analysis matrix , as shown in Figure 5.7,[49] is developed for each business case. One axis lists the potential solutions and the other contains a listing of risk categories. Potential solutions are rated as low, medium, or high risk in each category.

A risk matrix along with a project description, schedule, and resource estimate is then packaged together into a project outline for each potential solution. The project outlines are then reviewed by a Technical Review Committee (TRC). Based on the information contained in the project outlines, the TRC recommends a final solution for each problem. The recommendations are then reviewed and approved by an Executive Review Committee.

[49]Ibid.

Risk Category	Potential Solution				
	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5
Non-Compliance within Timeframe					
Non-Compliant Technology (Solution)					
Failure to Accurately Forecast Requirements					
Adverse Impact on Production Performance					
Adverse Impact on Product Quality					
Adverse Impact on MDAE Finances					
Excessive Design/Documentation Changes					
Adverse Impact on Future Production Contracts					
Non-Compliance with Future Regulations					

Figure 5.7. Risk Analysis Summary Matrix

Once approved, the collection of business case studies and project outlines of the approved projects make up the Compliance Plan. The Implementation Plan contains project work plans that document the work to be accomplished by each project, a project schedule, staffing requirements, and a detailed budget. Resource impacts are projected by year. This information is then provided for incorporation into unit and program business plans.

The use of a planning process in the compliance paradigm is an important difference between the compliance paradigm and the other two paradigms. The characteristics of the compliance paradigm are listed in Table 5.14.

Each of the other companies studied has a less formal process for reviewing compliance requirements within their environmental management and legal functions. The key difference between MDA-E and the other three companies is that the other compliance planning processes are neither comprehensive nor systematic. In addition,

pollution prevention is not a important driving force for carrying out the programs at the other three companies.

Component	Characteristics
Unit of analysis	- Pollution prevention is achieved by using source reduction techniques to meet environmental compliance requirements.
Process used for analysis	- Identify new environmental compliance requirements as early as possible to allow time to evaluate source reduction options for meeting the requirements (see Figure 5.6)
Organizing concepts	- Senior Management. The senior manager can be held legally liable for compliance. - Environmental Management. Responsibility for managing company compliance efforts is usually assigned to this function. - Engineering. Designers are responsible for meeting specific environmental requirements. - Research and Development. R&D is conducted on green products and processes.
General propositions	- An interdisciplinary planning process is central to paradigm. - Compliance requirements are seen as an opportunity to gain competitive advantage in products and processes. This may lead to consideration of supplier and customer requirements. - Environmental compliance planning can be carried out on any portion of the product life cycle. - When compliance is considered during design, potential cost savings associated with avoiding "end-of-pipe" treatment and disposal activities are at their maximum before capital expenditures on these items are made. - For new products, environmental compliance requirements are clearly stated as design requirements.

Table 5.14. Characteristics of the Compliance Paradigm

For example, LASC recently supplied the Air Force a kit for modifying the potable water system on the C-5B transport aircraft. The kit contained everything needed to make the modifications. One step in the modification involved making a new hole in the interior aluminum floor of the C-5B aircraft. To prevent corrosion around the new hole, a potting compound was specified. Emissions from the solvent used in the potting compound exceeded air emission requirements in California. Engineers at LASC were unaware of

the California requirements. Workers at Travis Air Force Base in California recognized the problem and asked LASC for an alternative potting compound, but none was readily available. The problem was solved by making the modification to the California-based aircraft in another state.

Also at LASC, the F-22's Hazardous Materials Program (HMP) addresses the compliance issue by setting up a coordination process between LASC and the Air Force (AF) on hazardous materials (HMs) compliance issues.

> The HMP shall coordinate, via the AF F-22 Focal Point, with AF Logistics base representatives to address AF user environmental compliance and hazardous materials concerns. The AF Base representative(s) will provide guidance regarding the AF base compliance of HMs proposed by the F-22 program in a timely manner. The F-22 shall use this AF guidance as the regulatory (including AFOSH) compliance determination for these HMs. The F-22 HMP will rely on AF guidance regarding the regulatory compliance of HMs used at AF bases.[50]

This coordination process, however, does not work. The coordination process is an "after-the-decision" process and it is not used regularly. As such, it will never provide timely input to the design process.

Another problem with the approach is that while logistics base representatives are knowledgeable about compliance requirements at their own bases, they have no source of data on the compliance requirements for bases located in other states. The military's logistics depots are large industrial complexes with environmental concerns similar to the aircraft manufacturer's concerns. The depots have large industrial areas that employ thousands of works and have correspondingly large environmental staffs. An environmental staff of fifty is not uncommon. Operating installations are more like commercial airports: their primary purpose is to operate aircraft, industrial activity is limited to maintenance activities, and environmental staffs are small, usually consisting of

[50]Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," 3-6.

three to seven environmental specialists. Thus, the F-22 coordination process provides neither timely nor complete environmental compliance information to designers.

The problem of design engineers not having information on the compliance requirements that will impact the use of a system also exists within the programs at MDA-E, but the company is working to correct the problem. The problem was identified in the first planning cycle of the strategic-planning process. In the first cycle, MDA-E set the planning boundary as all locations where MDA-E has facilities. This was a critical decision because MDA-E is under contract to provide logistics support, including base-level aircraft maintenance, for all of the Navy's T-45 training aircraft. This makes MDA-E responsible for the environmental compliance of its activities on Navy installations worldwide. The MDA-E planners discovered that no one at MDA-E was familiar with the environmental compliance regulations in most of these locations. This was seen as an unacceptable situation. MDA-E also discovered that none of the other aerospace companies "worried" about their customer's compliance problems, and saw its planning process as a means for gaining a competitive advantage by including results of a compliance planning process in the individual hazardous materials management plan (HMMPs) for each program.

While not all MDA-E programs yet have individual hazardous materials management plans (HMMPs), Figure 5.8[51] illustrates the relationship that will exist between program HMMPs and the MDA-E compliance plan once each program has a HMMP.

Figure 5.8 also illustrates that, as currently implemented, MDA-E's strategic plan addresses the company's business activities, which are largely associated with manufacturing. Their strategic plan does not address most program life cycle issues

[51]Richard E. Pinkert, "Overview of McDonnell Douglas Aerospace - East Environmental Assurance Organization," discussion charts provided during interview by author, McDonnell Douglas Corporation, St. Louis, MO, 10 November 1993.

beyond manufacturing; however, the strategic planning process could easily be used to address a customer's program-specific environmental compliance requirements as a part of a program HMMP. This is the direction in which MDA-E is moving.

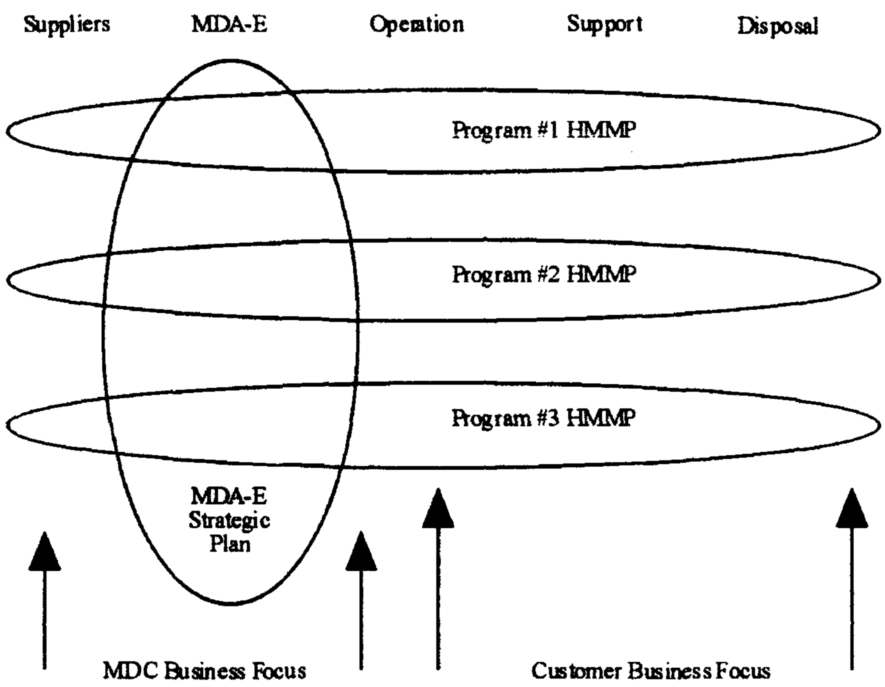

Figure 5.8. Relationship Between the MDA-E Strategic Plan and Program Hazardous Material Management Plans (HMMP)

5.3.4 Analysis

In this section, the utility of each paradigms is explored. The analysis draws on comments made by people involved in using each paradigm and on their ideas for improvement. In particular, the analysis focuses on problems that are rooted in acquisition policy and procedures.

5.3.4.1 Waste-Reduction Paradigm

At LFWC, goals and metrics are central to managing and evaluating the pollution prevention program. As their implementation illustrates, a comprehensive program

requires multiple goals and metrics. In current Air Force system acquisition programs, there are only broad pollution prevention goals and there are no metrics.

This occurs because the government has not defined what it wants to accomplish in its acquisition pollution prevention efforts. The Air Force has recently tried to address this deficiency by tasking all program mangers to track the use of ozone depleting chemicals and the seventeen chemicals in the EPA's 33/50 Program.[52] The Air Force's goal is to reduce both the number of uses and the pounds used by 50% by 31 December 1996, based on a 31 December 1992 baseline. Quarterly reports are to be submitted to the Air Force staff showing the number of processes that use each chemical[53] and the total pounds used.[54] If implemented, this initiative will have a major impacts on acquisition programs.

Since the program is tracking the number of process that use each chemical along with the number of pounds used, it is requesting different data than the 33/50 Program which uses toxic releases inventory reports (which are already required) to track chemical releases. This imposes a major new reporting requirement for both industry and the Air Force. Funds for implementation are to come from restructuring each program.[55]

By requesting chemical use data, the Air Force is moving in a direction that many environmentalists advocate for the EPA. The EPA is considering the development of a chemical use inventory but has not made a final decision even though, "activists have long championed such data as essential for pollution prevention."[56]

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[52]Darleen A. Druylin, Deputy Assistant Secretary of the Air Force (Acquisition), Memorandum for commanders, 'Pollution Prevention on Air Force Acquisition Programs," 23 December 1993.

[53]The number of processes or product applications required by applicable technical data (i.e., engineering data, specifications, and technical orders).

[54]Amounts installed on the system and purchased for manufacturing, operations, and support, reported in pounds.

[55]This means that additional funding will not be provided and that the number of systems purchased, the delivery timing, or other means must be used to make funds available within each program's existing budget.

[56]Working Notes on Community Right-To-Know, "Use Inventory Advances," (Washington D.C.: United States Public Interest Research Group, March 1994), 1.

The negative aspects of the Air Force's initiative parallel the issues already raised concerning the waste-reduction paradigm. The 33/50 Program chemicals and the reduction goals were arbitrarily set. The relative risks of the these chemicals in comparison to other chemical being used was never assessed. By focusing on the 33/50 Program chemicals larger risks from other chemicals may be ignored and attention may be diverted from fully evaluating new advanced and classified materials that are being developed to meet the performance and technology requirements of DoD systems.

An alternative way for the Air Force to proceed would be for the government to defines its values, requirements, and goals, on a program-by- program basis based on an assessment of each program. Then, the government and contractor could jointly develop an appropriate set of metrics for measuring progress. This method of developing requirements for each program is the method used to specify most system parameters.

5.3.4.2 Design-Materials Paradigm

LASC's experience using this paradigm has generated three operational issues. First, what is a hazardous material? This is an important question because the procedures for implementing the paradigm begin with identification, but answering the question is not easy. LASC and the AF agreed that any material that requires an elevated level of management would be treated as a hazardous material.[57] Leaving the definition open to broad interpretation is working in current contracts and, so far, there has been no problem with a non-responsive contractor. As these procedures are applied to more and more contracts, the issue will arise when a questionable material is provided to government in a system. Since the definition of what is hazardous is key to successful design management, better guidance is needed.

[57]Since no one has defined what is meant by "an elevated level of management," the definition is not very practical. In addition, it is not enforceable from a contract management point of view.

Second, the system requirements for the F-22 did not include any environmental requirements.[58] System requirements (which include environmental requirements) become the criteria in considering trade-offs in the design decision process. This places the designers in the position of trading off well defined requirements for cost, strength, safety, etc. against a general desire to use less hazardous materials. Without specific criteria, the IPTs will try to satisfy their "hard" criteria before worrying about "soft" criteria. This does not mean that all environmental criteria should be "hard" criteria. It does mean that the government must specify "hard" criteria where it is appropriate and must have a process to develop the individual criteria or values for each program--a process that does not now exist. As in the compliance paradigm, the lack of clear pollution prevention requirements is a critical omission. One industry engineer summarized the problem when he stated, "The government must provide black and white requirements. We bid and live to the letter of the contract."

Third, even if environmental requirements are developed early in the program, innovations in environmental management and technology may require additions, deletions, and changes. Since the acquisition cycle for a major system may extend upwards of twenty years[59] the implementation procedures for the paradigm would be enhanced by including a process that provides inputs on lessons learned, new technologies and materials, and a continuing review of best practices that can be incorporated.

The aerospace companies are well prepared to handle the technology issues. Best management practices and lessons learned can be gathered. Finally, since the informational needs for individual programs overlap, the efficiency of gathering and

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[58]The following statements are examples of environmental requirements: Cadmium plating shall not be used on landing gear parts. Paint for interior surfaces shall have a volatile organic compound (VOC) content of less than 420 grams per liter.

[59]The F-22 program's requirements were developed in the early 1980s, Demonstration/Validation contracts were awarded in 1984, and the current Engineering and Manufacturing Development contract was awarded in 1991. Production aircraft will not be built until after 2000.

distributing the needed information can probably be enhanced by adopting a set of procedures that improves information sharing among programs.

5.3.4.3 Compliance Paradigm

Using this paradigm, MDA-E is able to deal with the dynamic nature of environmental regulations. In the systems acquisition process, the only dynamic variable the process recognizes is the intelligence threat assessment. The threat assessment is updated regularly and is evaluated at every program review. Conversely, the program manager is tasked to minimize changes to all of the other program variables such as cost, schedule, range, speed, weight, etc. While it may be desirable to avoid changing most program variables, it is impossible to develop a new weapon system without adapting to changes in environmental regulations which, like the threat, are external to the program and beyond the program manager's control.

For example, since the early 1980s when the F-22's requirements were first developed, there have been tremendous changes in U.S. environmental laws and regulations and before the first production aircraft is delivered there will be more changes. Major revisions to the Clean Water Act and the Resource Conservation and Recovery Act are now being considered in Congress. Current acquisition management procedures do not recognize this dynamic feature of environmental regulations.

5.3.4.4 Multiple Evaluation Criteria - A Common Issue

The evaluation step in each paradigm uses multiple criteria for decision making. The criteria used include environmental factors as well as product and business related factors such as quality, manufacturing time, cost, etc. Each also uses a qualitative risk evaluation process for providing insight to decision makers on trade-offs that are involved in each alternative.

This range of decision criteria is not currently recognized in acquisition policy. DoD Directive 5000.2 states that, "The selection, use, and disposal of hazardous materials in

the systems acquisition process shall be managed over the system life cycle so that the DoD incurs the lowest cost required to protect human health and the environment."[60]

This elevates life cycle costs above all other criteria, and at least in the short term, no one in industry has a model for calculating life cycle costs for individual hazardous materials with an acceptable degree of uncertainty. Given this situation, the policy is being ignored.

5.3.5 Paradigm Summary

Industry is implementing pollution prevention using three paradigms with different starting points for analysis: 1) wastes, 2) design materials, and 3) environmental regulatory compliance. As implemented, none of the paradigms is adequate for accomplishing broad-based pollution prevention that addresses the entire system life cycle. In addition, more than one paradigm is used at each company studied.

The waste-reduction paradigm is based on the waste minimization concept and is the most widely used of the three paradigms. Organizationally, the environmental management function is responsible for implementation at all four companies. Perhaps their biggest challenge is getting the engineering design professionals involved in the process.

The design-materials paradigm focuses attention on the materials selection process at the beginning of design. In this paradigm, the potential wastes and environmental impacts associated with using a material are not always well understood at the time a decision is made. Designers are central to this paradigm since its focus is the design process.

The compliance paradigm looks at environmental compliance regulations as opportunities for applying source reduction techniques. The effort is often centered in the

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[60]US Department of Defense, "Defense Acquisition Management Policies and Procedures," Department of Defense Directive (DoDD 5000.2, 23 February 1991.

environmental management function, but other functional areas may have a leading role as well.

In examining the how the paradigms are being implemented in the acquisition programs managed by each company, one or more government inputs were absent in each program (including environmental requirements, criteria, and goals) reducing the effectiveness of each approach. Finally, the acquisition process does not recognize the dynamic nature of environmental regulations in the U.S.

5.4 Implementation Contextual Factors

In the case studies, seven implementation contextual factors commonly cited in the implementation literature as being important for understanding an implementation process were observed: 1) organizational structure, 2) communications, 3) resources, 4) dispositions, 5) decision making, 6) goal structure, and 7) the knowledge base. Observations concerning the impact of the first five factors on pollution prevention implementation are presented below. Observations on the sixth factor, goal structure, were included the section on pollution prevention paradigms. The seventh factor, knowledge base, was not a concern at any of the companies because of the technical capability available within each company. Observations on the knowledge base at each company are included in the individual company case studies in the appendices.

5.4.1 Organizational Structure and Relationships

Organizational structure is an important factor in implementing pollution prevention in large complex organizations since pollution prevention opportunities span across functional and program lines. To overcome the vertical and horizontal differentiation in organizations, integration is needed. Of the two types of differentiation, the problems associated with horizontal differentiation, or departmentalization, are causing the greatest

organizational challenges to pollution prevention implementation in the cases studied. The three primary types of departmentalization are: 1) function, 2) product, and 3) location.[61]

Integration is defined as the process of achieving unity of effort among the various organizational elements. "Through the processes of vertical and horizontal differentiation the activities required for organizational performance are separated. They then have to be integrated."[62] Many methods for achieving integration have been developed, but according to Kast and Rosenzweig, the influence of most successful integrators stems from their professional competence rather than from their formal position. In addition, they are successful because they represent a central source of information in the organization.[63]

Since the pollution prevention objectives in the cases studied almost always span functional and program lines and sometimes span across locations as well, integration is required to bring together the needed expertise to address specific problems. This situation occurs because pollution prevention initiatives often involve many functional experts (production, manufacturing, design, research and development, purchasing, logistics, environmental management, industrial hygiene, medical, etc.), that are not all regularly included in daily functional and program decision making processes.

Thus, in the organizations studied, assigning pollution prevention to the environmental function is not likely to be very successful without some additional means of integration and coordination. A typical functional and product organizational matrix is illustrated in Figure 5.9, where the functions are represented by the columns and the projects are represented by the rows.

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[61]Fremont E. Kast and James E. Rosenzweig, Organization and Management: A Systems Approach, 2nd ed. (New York, NY: McGraw-Hill, 1974), 241-216.

[62]Ibid., 221.

[63]Ibid., 223.

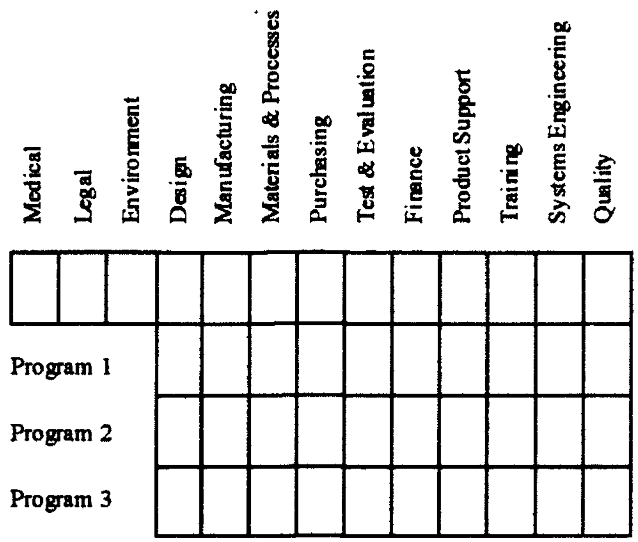

Figure 5.9 Functional and Product Organizational Matrix

The figure shows the medical, legal, and environmental staffs as "special" staff functions that are part of the core organization, but do not supply employees to the programs as part of a matrix organization. At each of the companies studied, the core environmental function is organized as special staff that consists of less than twenty-five employees that must support the entire company. This type of organization leads directly to the need for integration among the functions and coordination between functions and programs.

Common approaches to integration and coordination include using committees, task forces, teams, project offices, the hierarchy, and the administrative system.[64] In the companies studied, all three types of departmentalization exist in each company, but the approaches selected for trying to improve integration and coordination differ widely. The differences in each company's approach to integration and coordination and the impact the approach is having on pollution prevention implementation are discussed below.

[64] Ibid., 222-224.

5.4.1.1 Lockheed Aeronautical Systems Company

LASC is organized along product and functional lines. Figure 5.10 shows a partial organizational chart for LASC and includes subdivisions important to the company's F-22 and overall pollution prevention efforts

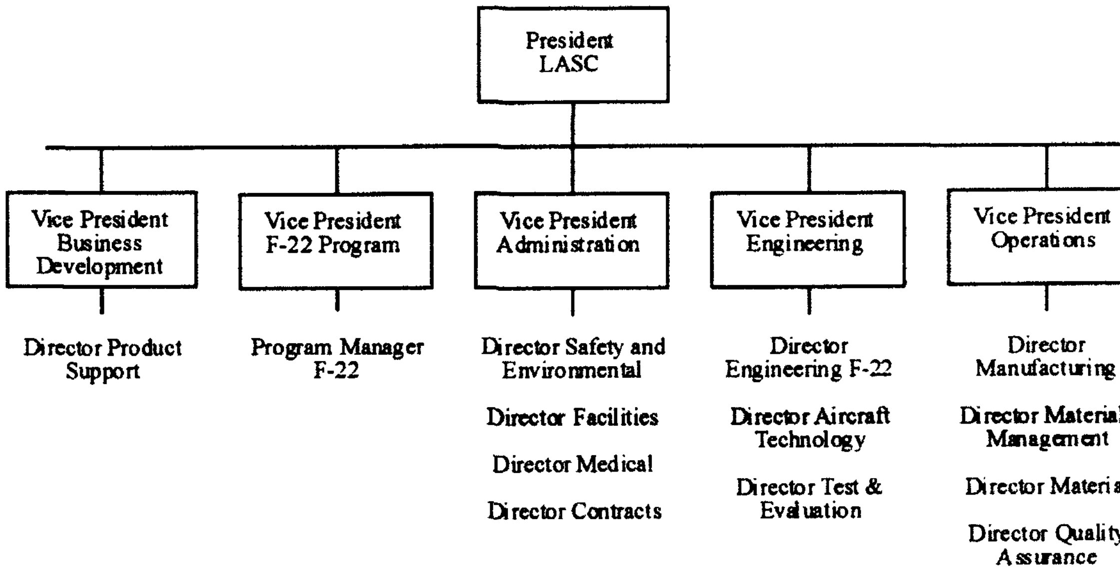

Figure 5.10. LASC Organizational Structure

According to Mr. Blackwell, LASC President, the current organizational structure was designed by LASC's Lean Enterprise team with four principal objectives:

1. Organize all company functions by lines of business (LOBs) through projectizing
2. Implement integrated product teams (IPTs) throughout the company.
3. Organize around processes.
4. Reduce the layers of management and optimize the span of control by increasing the number of employees assigned to each manager.[65]

Within projects, the organization is structured along both traditional functional lines and product lines. For example, there are eleven functional chief engineers working for the

[65]Micky Blackwell, "Lean Enterprise Focuses on Re-engineering LASC Organizations." Star (Lockheed Aeronautical Systems Company), 6 August 1993, 2.

Director of F-22 Engineering, one of the staff directors shown in Figure 5.11.[66] In addition, the F-22 program is also structured into product teams headed by product managers. On the F-22, each product manager heads an integrated product development organization that is made of up multiple levels of individual integrated product teams (IPTs). An example of an integrated product team (IPT) structure is illustrated in Figure 5.18. Integrated Product Development Structure (see page 149 below).

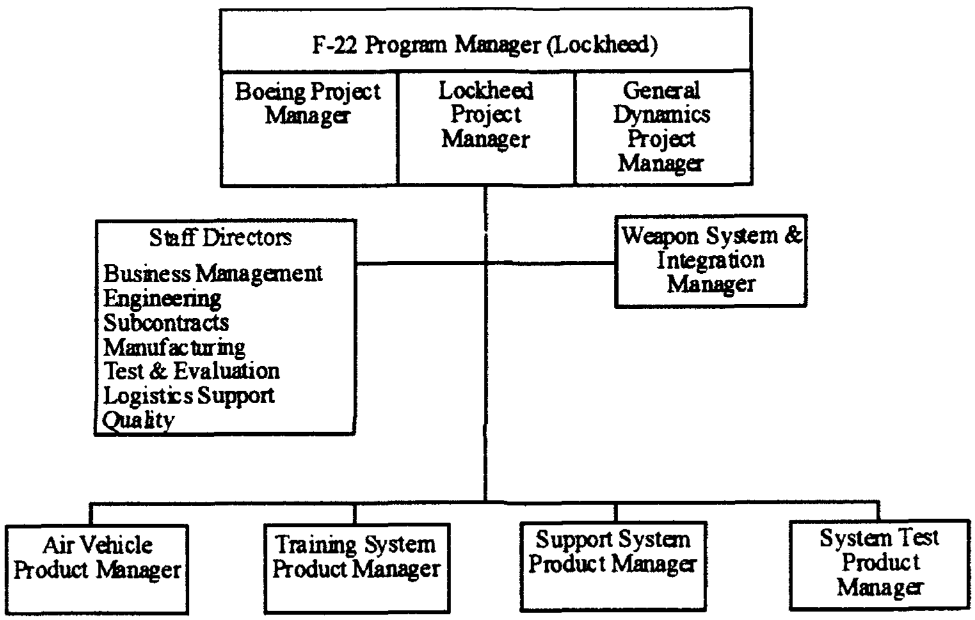

Figure 5.11. F-22 Team Program Organization

Pollution prevention activities on the F-22 project are assigned to the Hazardous Materials Manager. The Hazardous Materials Manager's program and functional organizational chains are shown in Figure 5.12.[67] The program chain runs from the Engineering Director through system safety. The Hazardous Materials Manager's

[66]The list of chief engineers includes structures; vehicle integration and integrity; flight sciences; weight control; airframe & systems design; configuration, analysis and integration; avionics; flight test; system engineering; computer resources; and systems technology.

[67]Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," 3-3.

professional background is materials engineering. The functional chain runs through the core Safety and Environmental Director to Program & System Safety.

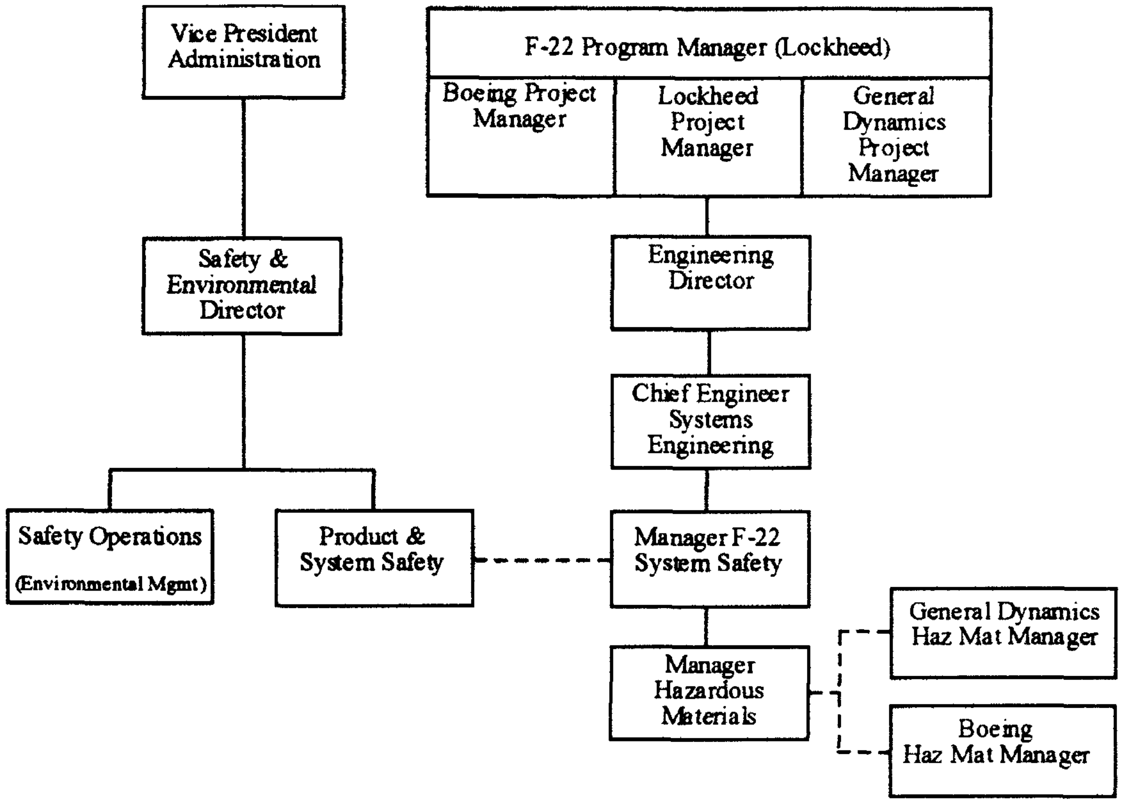

Figure 5.12. F-22 Hazardous Materials Organization

Within the core Safety and Environmental function, which is shown on the left side of Figure 5.12, the primary pollution prevention responsibilities are assigned to the environmental portion of the organization. At LASC, the environmental management function is called Safety Operations and it also reports to the Safety and Environmental Director. This arrangement (assigning the F-22 hazardous materials program to the system safety function) appears to have been established because the F-22 program has its own system safety function it does not have an environmental function. With only one Hazardous Materials Manager, it is impossible to actively participate on the dozens of

IPTs that are responsible for designing the system. Thus, the manager's primary job is coordination and integration.

To support these efforts, LASC has developed two "coordinating" teams: the Hazardous Materials Review Board (HMRB) and the Pollution Prevention Committee (PPC). Both the HMRB and the PPC consist of core functional representatives that provide input to functional and program staffs. The HMRB provides input on individual hazardous material use decisions and operates as described in the design-materials paradigm. The PPC is responsible developing the company pollution plan and operates using the waste-reduction paradigm.

As noted in Section 5.3.4.1, the HMRB is successfully fulfilling its role of conducting technical evaluations of hazardous materials and coordinating recommendations. The HMRB, as a secondary role, also provides some integration on hazardous materials issues.

The PPC was still being organized at the time of the site visit. Its role is envisioned to be similar to that of the Hazardous Materials Management Program Office (HMMPO) at LFWC.

5.4.1.2 Lockheed Fort Worth Company

LFWC, unlike the other companies, is basically organized along functional lines. The exception to this is the F-22 program. This functional organization is the result of having only one production program, the F-16, for an extended period of time.

As shown in Figure 5.13, the environmental function at LFWC is assigned to the Vice President for Human Resources and the Director of the Hazardous Materials Management Program Office (HMMPO) reports to the Vice President.

The HMMPO is probably best described as a standing environmental working group, but it can also be viewed as an environmental integrated product team. The HMMPO operates using the waste-reduction paradigm and has two main two roles: 1) a

problem solving team, and 2) as the integrator and coordinator of environmental activities at LFWC. The existence of a multi-disciplinary environmental group or committee is nothing new to industry or to government. Getting this type of environmental group to function effectively is much less common.

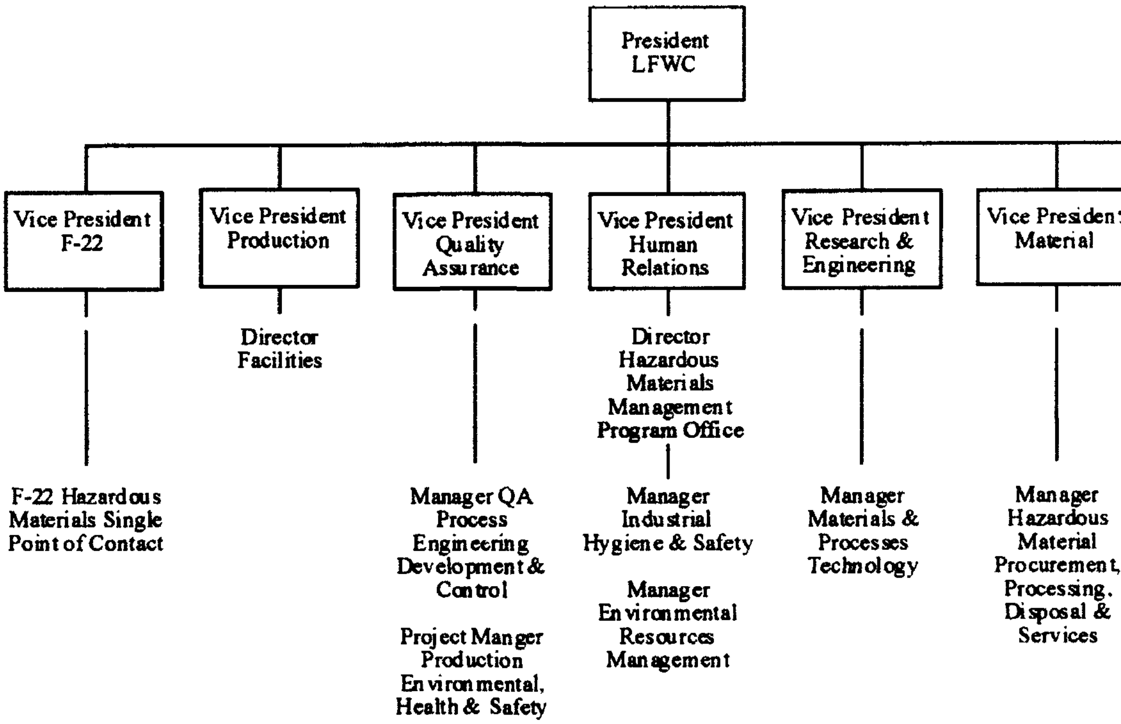

Figure 5.13. LFWC Organizational Structure

In LFWC's case, several factors have come together to produce a successful program office. First, the HMMPO has top management support. Second, the HMMPO is a working group charged with solving problems. Third, LFWC is implementing integrated product development throughout the company. This works to help change the company's culture on working in multi-functional teams. Fourth, and most important, the HMMPO has strong goal-directed leadership.[68]

[68]This goal-directed leadership style is discussed in Section 5.5.1.2.

The HMMPO's structure is shown in Figure 5.14. The members of the HMMPO meet weekly to coordinate actions in the factory and, to a lesser degree, to integrate and coordinate environmental activities with the F-22 program.

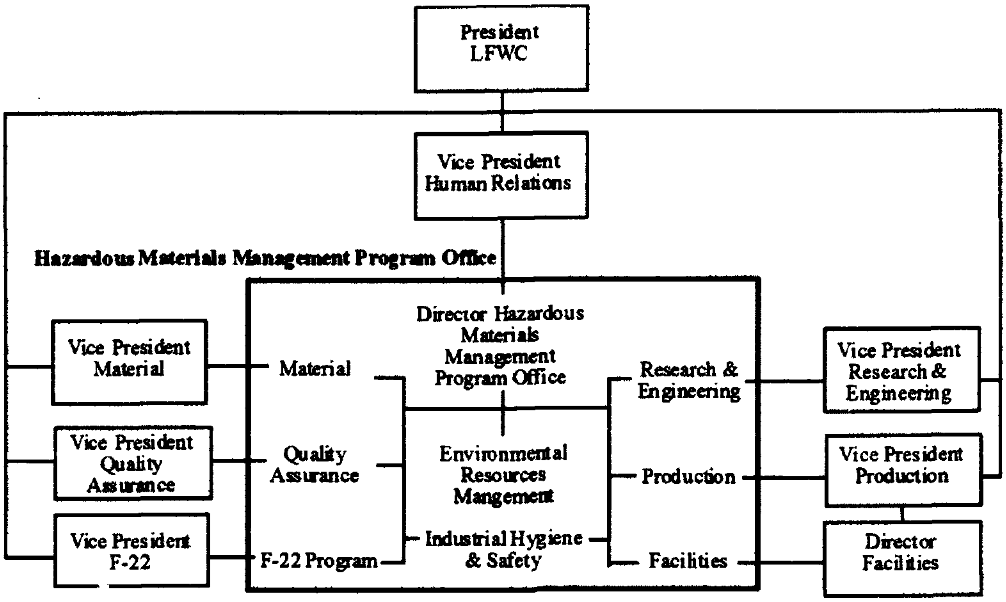

Figure 5.14 Hazardous Materials Management Program Office (HMMPO)

For the F-16 program, the HMMPO is directly involved in every aspect of pollution prevention from ordering and storing materials, to developing new processes, to disposing of wastes. The structure works well because all the major functions are represented within the HMMPO and the senior management is committed to making it work.

On the F-22 program, the role of the HMMPO is less clear. The F-22 is a product oriented development team and the HMMPO is outside the program. The HMMPO uses a goal-oriented management style,[69] but the F-22's hazardous materials program is process oriented. One potentially important role for the HMMPO is reviewing new materials proposed for use on the F-22 that are not already used on the F-16. So far, however, this has been a small role since less than five new materials have been proposed

[69]See section E.6.3.2 for an explanation of the goal-oriented process.

for LFWC's portion of the F-22. Thus, HMMPO has had a much smaller role in the development of the F-22 than the Hazardous Material Review Board (HMRB) at LASC.

5.4.1.3 McDonnell Douglas Aerospace - East

The MDA-E organization can be roughly divided between business units and support units as shown in Figure 5.15. Responsibility for providing environmental support to the business units is divided between the Director of Occupational Safety, Health, and Environment and the Director of Environmental Assurance

The Director of Occupational Safety, Health, and Environment (OSHE) works for the Vice President for General Services. This organization also includes Administrative Services, Transportation, Employee Relations, Facilities, and Security. Historically, the environmental function was a part of Facilities before being combined with Occupational Safety and Health to form an integrated OSHE organization.

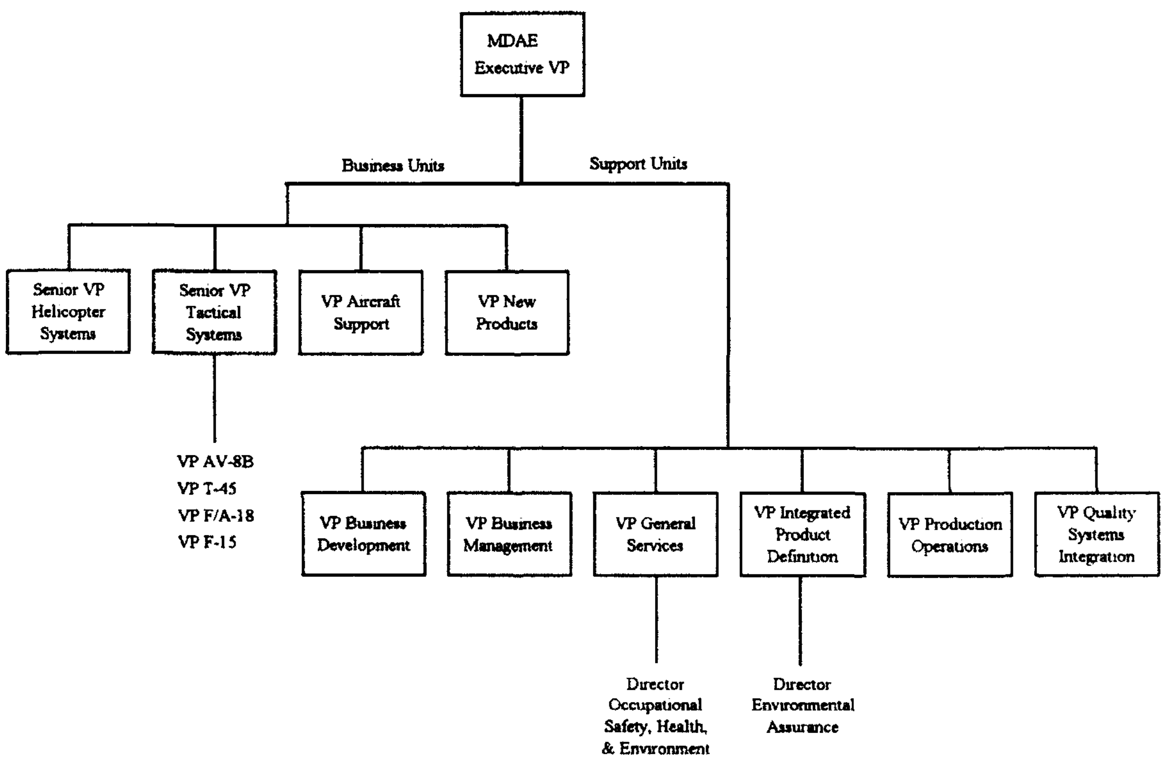

Figure 5.15. Partial MDA-E Organizational Chart

The OSHE Director has a manager for each OSHE function. The Environmental and Hazardous Materials Services (EHMS) Manager has a staff of approximately twenty-five people divided into four groups. The four groups cover 1) operation of treatment facilities; 2) hazardous and solid waste management; 3) hazardous materials control; and 4) pollution prevention (air, water, and other compliance).

The EHMS organization is primarily responsible for regulatory compliance with environmental and hazardous material transportation regulations, operation of treatment facilities, and coordination of MDA-E environmental programs through the Environmental Compliance Committee. EHMS also is responsible for pollution prevention for facility systems. For example, EHMS is responsible for planning to eliminate ozone depleting chemicals (ODCs) from facility air conditioning systems. Environmental Assurance, on the other hand, is responsible for eliminating ODCs in production operations.

The Director of Environmental Assurance (EA) reports to the Vice President for Integrated Product Development (IPD). This organization includes most of the "core" functional organizations that set technical policy and supply specialists to support individual programs. IPD is made up of eight major functions and includes Engineering, Manufacturing Processes & Definition, Quality Engineering and Planning, Flight & Laboratory Operations, Product Support, IPD Processes and Tools, and Supplier Management and Procurement.

EA was formed by "pulling" people from throughout the IPD organization with strong support from its Vice President. While the majority of people have engineering backgrounds in materials and processes, EA also has a good mix of professionals with other backgrounds such as logistics, planning, and procurement.

This integration of people with different functional backgrounds into a single environmental organization is unique among the companies visited. Others are trying to achieve integration using committee structure, but no one else has put the people together into one office.

With this mix of backgrounds, EA is significantly different from EHMS where most of the staff have backgrounds in environmental engineering and facilities management. A further difference between EA and EHMS involves the career paths of the staffs. While most of the EA staff have worked in one or more programs during their careers, very few in EHMS have program experience. These differences are reflected in each organization's focus.

As shown in Table 5.15, EHMS is focused on permits, regulatory reporting, compliance and hazardous materials management, and operation of treatment facilities. EA, on the other hand, is primarily concerned with planning for new materials and production processes to support MDA-E product development and production. In creating EA, IPD's Vice President recognized the need to integrate environmental thinking and planning into the core technical functions at MDA-E.

Environmental and Hazardous Materials Services (EHMS)
(Regulatory Compliance & Risk Management)
- Hazardous Materials Control
- Pollution Prevention
- Waste Management
- Environmental Operations
- Environmental Compliance Committee
Environmental Assurance (EA)
(Process Improvement & Technology Development)
- Hazardous Materials Minimization
- Engineering Technology
- Product Design and Support
- Planning and Studies
- Process Action Team (Forward Pricing)

Table 5.15. MDA-E Environmental Responsibilities

Integration with the programs is being accomplished using functional points of contact in each program. For example, hazardous materials selection and manufacturing process issues are coordinated between EA and a member of each program's materials and

processes staff. Similarly, EA has program points of contact on each program's product support staff.

5.4.1.4 Pratt & Whitney

The F119 program is managed at P&W's Government Engines & Space Propulsion (GESP) unit in Florida, but key support is provided by P&W's manufacturing staff located in Connecticut. Because all manufacturing is done in Connecticut, P&W has greater location departmentalization than at the other companies studied. The important relationships for pollution prevention are shown in Figure 5.16.

The functions shown on the right side of Figure 5.16 are located in Connecticut. Those on the left side are located at the GESP facilities in Palm Beach County, Florida.

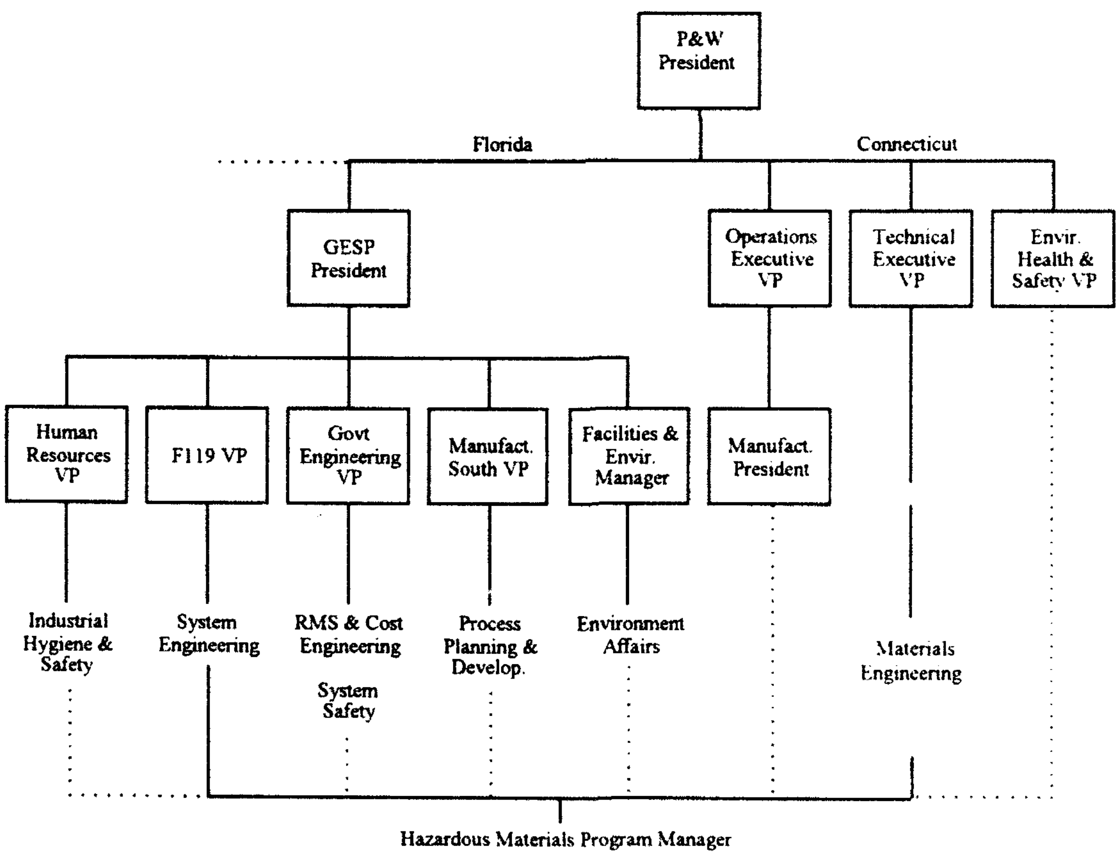

Figure 5.16. Partial P&W Organizational Chart

Important company functions located in Connecticut include engineering, operations, and environmental policy. Guidance on engineering and materials issues is provided by organizations that report to the Technical Operations Executive Vice-President. All production engines are manufactured by Operations personnel and P&W environmental, health, and safety policies are set by the Vice-President for Environment, Safety, and Health.[70]

Integration of pollution prevention activities at GESP is being accomplished using three primary integrating mechanisms: 1) the P&W Group, Consolidated Pollution Prevention Team (CPPT), 2) the P&W Group, Charter Parts Council (CPC), and 3) assigning pollution prevention responsibilities directly to the major functional staffs. The Consolidated Pollution Prevention Team (CPPT) is responsible for developing and maintaining the P&W pollution prevention plan and for coordinating the efforts of three working groups: the Waste Minimization Steering Committee, the Environmental Technology Team, and the Environmental Design Team.

The Charter Parts Council (CPC) is a P&W concurrent engineering activity that focuses on parts instead of on products. Within the CPC, families of similar parts are grouped under a CPC team that is tasked to produce a "norm" for each family. The norm addresses part configuration, materials, and production processes. Environmental and pollution prevention guidance is provided to the teams for incorporation into the norms. Overall, the are 63 CPC teams that maintain norms for over 95 percent of P&W parts.

The final integration method involves assigning responsibility for pollution prevention issues directly to functional areas. In the design process, responsibility for hazardous materials selection, use, and waste minimization in manufacturing as been assigned to Materials Engineering. The Material Engineering functional area is many times

[70]At GESP, only facility type environmental issues are handled by the Environmental Affairs Group. The group reports through the Facilities and Environment Manager to the GESP President. The group gets its functional guidance from the company's Environment, Safety, and Health organization.

the size of the company's environmental staff, employing hundreds of engineers. In addition, every program IPT must have at least one materials engineer as a member of the team. In this approach, there is an individual in every IPT with functional responsibility for hazardous materials pollution prevention.

How the three integration methods interact on a program will be illustrated using the F119 program. P&W's approach to implementing pollution prevention in the F119 program is centered in its implementation of integrating product development. Figure 5.17 shows the program's overall management structure and includes both the line and staff functions. At P&W, like the F-22 structure at LASC, functional managers support the program, but are not directly responsible for the program.

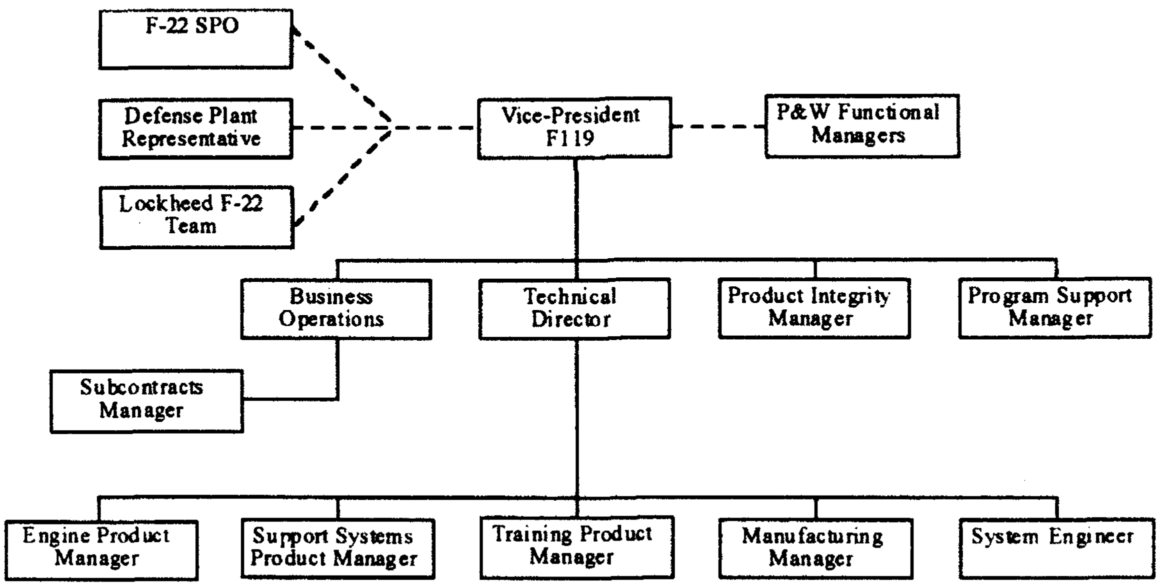

Figure 5.17. F119 Program Organization

Figure 5.18 shows the F119 integrated product development team structure that is being used to implement P&W's integrated product development process.[71] Individual

[71]The IPT structure is organized around the three product managers: engine, support systems, and training. Below the product level there are component level teams. At the component level, team managers are responsible for a major portion of the product as defined in the program's work breakdown

IPTs are at the lowest level of the structure and they have responsibility for one or more parts of a product. Design of individual parts is guided by the CPC norms. IPTs may deviate from the norms, but must have good reason for doing so.

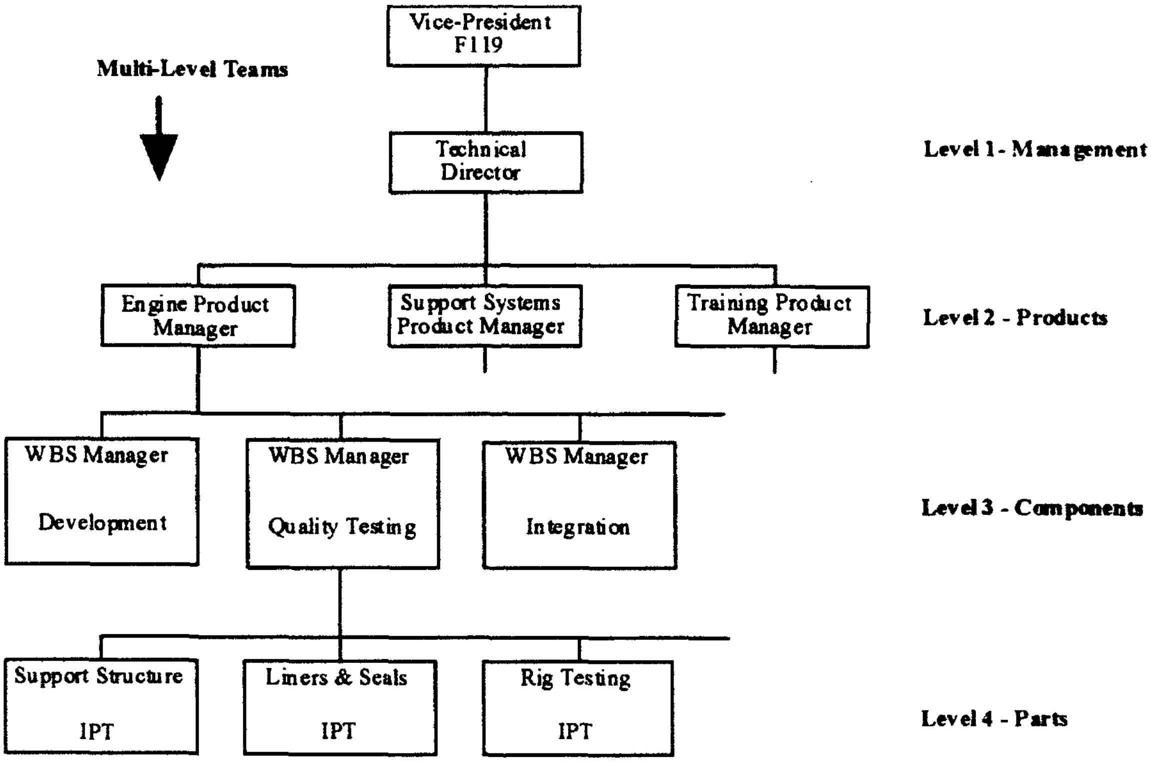

Figure 5.18. Integrated Product Development Structure

Since design decisions are made by the integrated product teams (IPTs), the success of this approach rests with having knowledgeable people on the IPTs with expertise in all the functional area needed for the team to make balanced design decisions.[72] IPTs are usually headed by a design engineer. In addition to engineering, team members usually include materials engineering; customer support; the producer (either P&W manufacturing

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structure (WBS). These managers have the primary responsibility for controlling costs and meeting technical requirements and milestones.

[72]In a traditional development, the management process and structure would follow functional lines such as structures, electrical, mechanical, manufacturing, materials, etc., instead of being organized around the products and their logical components and parts.

or the external supplier); finance; and the customer. Other functional representatives are included as needed.

Within the IPT structure, primary responsibility for providing technical expertise on pollution prevention is assigned to the IPT's materials engineer. The materials engineer is also responsible for bring the "organizational expertise" on pollution prevention to the IPT, including the work of the Consolidated Pollution Prevention Team. Other IPT members are responsible for pollution prevention within their specific areas of expertise. For example, the logistics representative is responsible for providing input on maintenance and repair materials and processes.

On the F119 program, Hazardous Materials Program (HMP) manager reports through the F119 Systems Engineering Manager for program issues and through Materials Engineering for functional technical guidance. The HMP manager is responsible for implementing the contract HMP provisions. In addition, he is the single point of contact for external organizations on F119 hazardous material pollution prevention issues.[73]

Unlike the Hazardous Material Program (HMP) manager at LASC on the F-22, the F119 HMP manager has technical representatives within each IPT with assigned pollution prevention responsibilities. In LASC's approach, there is an overall team responsibility for pollution prevention assigned to each IPT, but no one team member is specifically tasked or trained to carry out the tasks associated with the responsibility. While the materials engineering organizations at all the companies studied play an important role in pollution prevention, only P&W has formally assigned pollution prevention responsibilities to this function.

[73]Outside the IPT structure, various functional managers also have pollution prevention responsibilities. The role of the environmental staff includes technical expertise, interfacing with regulatory agencies, and providing information on environmental regulations to the IPTs.

5.4.1.5 Organizational Structure Summary

Integrating pollution prevention across functions and programs is a significant challenge. At LASC and LFWC, committee, teams, and boards have been development to perform the integrating function. At MDA-E a new function, Environmental Assurance, was created and staffed with functional representatives from the other functional staffs. In addition, a pollution prevention committee with working groups is used to solve specific manufacturing and facility issues. At P&W, integration is being accomplished with a pollution prevention committee, a Charter Parts Council, and by assigning pollution prevention design responsibility to Materials Engineering, a large and well established technical function.

At both LASC and LFWC, the integration structures are able to accomplish specific integration tasks, but are not well suited to integrating among functions and programs on a comprehensive basis. MDA-E and P&W have developed new functional arrangements to try to cope with the need for more comprehensive integration. While both initiatives are still evolving, both look more promising than trying to bridge the functional and program structures solely with committees, teams, and boards.

5.4.2 Communications

According to Edwards, "The first requirement for effective policy implementation is that those who are to implement a decision must know what they are supposed to do."[74] In considering communication of pollution prevention policy to the implementers, three general areas will be examined: 1) policy transmission, 2) policy clarity, and 3) policy consistency.

Policy transmission within the companies occurs in a variety of ways. First, and most important, is the distribution of formal written policy. As was discussed in Section

[74]George C. Edwards III, Implementing Public Policy, (Washington, D.C.: Congressional Quarterly Press, 1980) 17.

5.2 Pollution Prevention Objectives, Strategies, and Policies, each company has written policies that address pollution prevention. The issue of whether company policies on pollution prevention have been received and understood is explored in detail in Section 5.4.4 Dispositions. Overall, the interviews conducted at each site indicate that the policies have been received and understood.

In addition to the transmission of formal policy, environmental and pollution prevention objectives, strategies, and accomplishments are transmitted through a variety of other means including procedures, design guidelines, pollution prevention committees, and other technical channels as well as through employee awareness training, company newsletters, and programs award. Some of the technical channels were discussed in Section 5.4.1 Organizational Structure and Relationships. Examples of some of the other channels being used are presented next.

At LFWC, the results of Environmental Resource Management's (ERM) employee environmental awareness and training efforts can be seen throughout the plant. There are frequent environmental articles in the weekly plant newsletter, posters are displayed everywhere, metrics are displayed for all to see, and a variety of training classes are held on a regular basis. ERM produces video tapes, quick reference guides, and leaflets in addition to posters. As a result of these efforts, the employee awareness program at LFWC is the most comprehensive seen at any of the sites visited in this research.

A good example of the strength of employee support that ERM has generated can be seen in LFWC's implementation of its environmentally complaint wipe-solvent[75] program. In addition to developing a set of low-VOC emission wipe solvents, LFWC discovered that the greatest emission in using wipe solvents normally comes from the wet rags following cleaning.

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[75]Wipe solvents refer to solvents that are used in small quantities to spot clean small surface areas. They are usually stored in small containers in the work area and are applied with a cloth or brush. The term "wipe solvent" is used since the solvents are often applied using a "wiping" action with a cloth.

> Even when placed in standard rag cans they continue to emit VOCs. The lower the vapor pressure, the slower this emission, but even low vapor pressure solvents eventually release all of the VOC's to the atmosphere. The approach taken was to place the wet rags in specially selected vapor-proof bags which eliminates the emission to the atmosphere.[76]

The bags are then collected and sent to an incinerator. The challenges in implementing the program were to get the workers to use the right solvent for each application: to put a minimum amount of solvent on a rag; and then after use, to put the wet rag into a special aluminized-plastic bag immediately after use and to then seal the bag. Making this work took an extensive education and awareness effort. The fact that the program is working, is a clear indication that the company's employee awareness is working.

At LASC, the Hazardous Materials Review Board (HMRB) has had a profound impact on opening communications on hazardous materials issues at LASC. The HMRB has achieved this by accomplishing its tasks efficiently and professionally. The review process for a new material is extensive and involves coordinating the efforts of many functional areas. The staff has been able to keep the length of time needed to complete a review and get the information to the board for a decision relatively short, usually under a month. When needed, the review process has been accomplished in less than a week. In addition to being timely, there is a knowledgeable and professional staff involved in the review process. This results in a decision package for each material that contains five to ten pages of factual information. Among the F-22 staff members interviewed, the HMRB process is well respected for providing documented, factual information and timely responses.

At P&W, communication with outside suppliers has been steadily improving. On the F119, P&W was required to report on the hazardous materials used in components

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[76]Henry J. Weltman and Tony L. Phillips, "Environmentally Compliant Wipe-Solvent Development," in the Proceedings of the Society of Automotive Engineers meeting held in Anaheim, California, 5-8 October 1992, (Warrendale, PA: Society of Automotive Engineers, 1992) 8.

purchased from outside suppliers. This helped encourage IPT members and subcontract managers to begin discussing environmental issues and to start becoming familiar with a supplier's hazardous materials and the resulting waste streams.

In addition to improving communications with its suppliers, improving the flow of information with its customers has been a major goal at P&W the last several years. In early 1993, Bear, Stearns & Company conducted a survey of P&W customers as part of their investment research on United Technologies. They found that,

> . . .Pratt's leading customers sensed a dramatic improvement in Pratt's customer service. Most emphasized Pratt had historically maintained a very arrogant and haughty attitude, one in which the manufacturer expected the customer to come to Pratt to do business. Unanimously, they noted material improvement in the company's customer service effort, a faster turnaround time between order and delivery, and, on balance, they indicated that Pratt seemed to be much hungrier, more creative, and more aggressive in pursuing new business opportunities. In fact, on six different occasions, customers suggested that the new Pratt & Whitney was much more customer-oriented and no longer had an arrogant attitude.[77]

The report also suggests that the improvement began, "within the past twelve months." This timing correlates well with the mid-1992 timing of the dramatic changes in P&W's environmental management efforts and suggests that senior management is successfully changing the organizational culture in a very broad way and that the changes include environmental issues.

Policy clarity is the second element in evaluating communications. At the operating company level, the major clarity issue involves how the program is to be carried out. Too often responsibility is assigned to a functional staff without a clear strategy for how the functional managers are actually to accomplish the objectives. Since pollution prevention impacts all programs and many functions, the responsible functional staffs must be able to influence other functional staffs as well as the program, project, and product management

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[77]S. Binder, "United Technologies Company Report," (New York, NY: Bear, Stearns & Company, 11 May 1993) 11.

organizations with the company. The relationships between functions were explored in Section 5.4.1 and its subsections.

At MDA-E, clearly communicating environmental issues to all levels of management was identified as one of the three specific Environmental Assurance (EA) strategies.

> Due to the magnitude of environmental issues facing MDA-E, it is important to accurately communicate the requirements for change, when changes must be implemented, and the areas impacted. . .[78]

The strategic plan is their primary tool for communicating significant environmental issues to management throughout MDA-E. A key method for communicating with the programs is through the product support representatives. A product support representative with responsibility for environmental issues has been appointed in every program. The representatives are used to coordinate issues between the programs and the core staff.

At P&W, the "Repair Team" provides an good example of why clarity is important. The Repair Team involves four organizations from three functional areas as shown in Figure 5.19. Repair Technology develops repair processes and materials. Repair Engineering develops repair procedures and specify logistical support. Repair Support Equipment is responsible for the equipment needed to support an engine and Technical Publications is responsible for technical manuals and other technical documentation.

Developing environmentally friendly repair procedures is a new task the Repair Team has undertaken. One of the goals of the effort is to provide pollution prevention information in a form usable by repair engineers. Providing the engineers a listing of acceptable and unacceptable chemicals did not prove to be an effective means of changing traditional chemical uses. Repair engineers do not "think" about repair tasks in chemical terms. They design complex repair tasks by specifying sequences of basic standard

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[78]Craig Green, "93 E.A. Strategic Plan Released," Environmental Assurance Newsletter. (St. Louis, MO: McDonnell Douglas Aerospace - East, October 1993) 1.

procedures. To address a chemical or process, one must change the standard procedures that call for the use of the chemical or process. Thus, telling the repair engineer to use MIL-C-87937 instead of P-D-680 is not effective. Instead, one must change the standard procedures that requires the use of P-D-680. Until this is done, MIL-C-97937 cannot be specified in repair tasks.

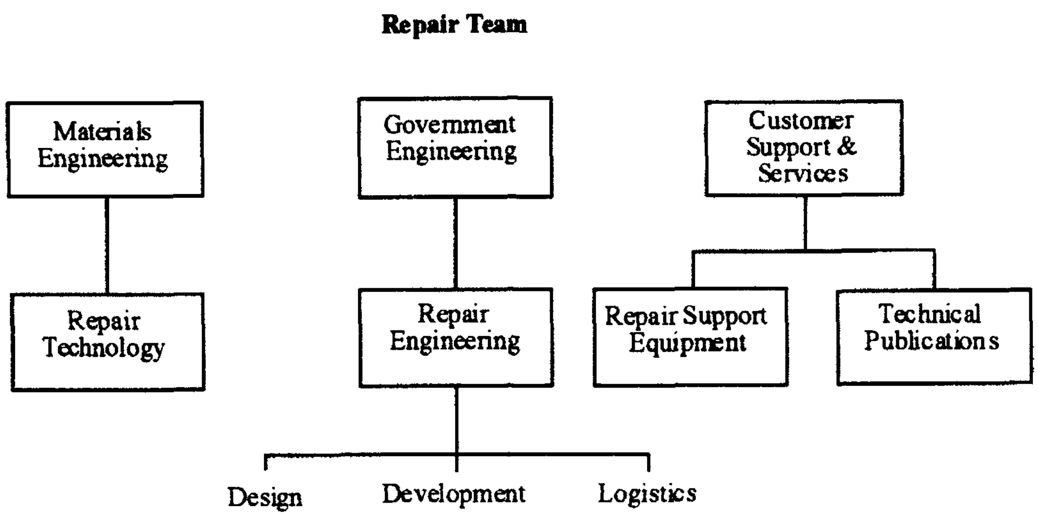

Figure 5.19. Pratt & Whitney, Government Engines and Space Propulsion, Repair Team

To help solve this problem, the repair team at GESP identified all of the standard procedures that call for one or more of the chemicals identified on the two lists the Air Force has provided. One list was provided by the system program office and includes the EPA 33/50 Program chemicals and several others. Another list was provided by provided by the Air Force engine repair depot at Kelly AFB, TX and includes chemicals regulated by the Texas Clean Air Act.

Using a combined listing, the team researched all of the primary and secondary references to the chemicals in the standard procedures. Primary references are standard procedures that call for one of the chemicals. Secondary references occur when one

standard procedure calls for the use of another standard procedure and the referenced procedure requires the use of one of the chemicals.

Using a matrix that the team developed, a repair engineer is now able to select acceptable standard procedures where they are available; however, getting the funding and labor hours needed to change the outdated standard procedures continues to be a problem.

The final communications element is consistency. Providing clear policy that is inconsistent with other policies is likely to disrupt implementation. Since the pollution prevention policies at each company are framed around basic social objectives, implementation is almost always in tension with basic objectives on products and profitability. Given this tension between basic corporate objectives, some flexibility in the means of achieving a social objective, such as pollution prevention, is needed. Based on the pollution prevention policy statements of the companies, lack of flexibility is not a problem.

At LASC, workers had limited access to information on hazardous materials in the work place in 1988. Material safety data sheets (MSDSs) were not available in most shops, many procedures did not explain how to use hazardous materials safety, and training on hazardous materials issues was not common. Today, this has all changed.

LASC has a strong hazardous materials management and control program. Two elements in particular stand out and they send a consistent message to employees that environmental, safety, and health issues are important. First, new computer hardware has been purchased to allow all MSDSs to be electronically scanned and stored. This will allow every MSDS at LASC to be available on-line. This is a great resource for both workers and designers, and solves the problem of updating paper MSDSs as they change.

Second, hazardous material receiving, storage, and issue are being consolidated in one organization within Operations. Staffed by well trained workers, the new Hazardous Materials Management function will provide close control of all hazardous materials from the time they are brought on site until they are either used in products, recycled, or

disposed. This level of attention to hazardous materials demonstrates management's commitment to improving day-to-day practices.

At MDA-E, a major limitation, and an inconsistency, involves access to "black" programs. A black program is a program whose existence is classified. Environmental personnel do not have access, or have very limited access, to many black programs at MDA-E. This is serious limitation and indicates that there is serious communications limitation between core functions and the programs.

With the exception of access to classified programs, the main consistency problem the companies face is one of not providing sufficient resources to accomplish their environmental objectives, thereby sending mixed signals to the workers. Resource impacts on pollution prevention implementation are discussed in the next section.

5.4.3 Resources

The key resource constraints impacting pollution prevention implementation are staffing and funding. Implementation of other policies often involves equipment, facilities, and other physical resources, but these generally were not serious constraints in the cases studied, except at government-owned, contractor-operated (GOCO) plants.

Of the four cases, MDA-E's core pollution prevention program has had the greatest success in competing for company resources. The number of core employees working on environmental issues has increased dramatically in the last two years while MDC's overall employment was dropping over the same time frame. This was do to the creation of the Environmental Assurance function which increased environmental staffing levels by approximately forty positions. This is in addition to the existing twenty-eight positions in Environmental and Hazardous Materials Services section which is responsible for day-to-day environmental compliance at MDA-E's facilities.

At the same time, there has been an extensive effort to reduce overhead costs within MDA-E; however, environmental programs have expanded. In addition, internal research

and development funding for environmentally beneficial projects has increased. As these examples show, MDA-E's core environmental functions have been relatively successful in obtaining resources, resources are still a serious constraint in its programs.

Some of the impacts of both funding and staffing resource constraints at MDA-E and at the other companies studied will be considered in the next two sections.

5.4.3.1 Funding

While top management at MDA-E controls the allocation of funding for its core "overhead" resources, it must negotiate the resources available in the programs. Getting the government to recognize and pay environmental costs is not always easy.

The F/A-18 was designed twenty years ago and has been in production ever since, but more changes will occur in the production processes in the next two years than since production began. MDA-E is negotiating the cost for building thirty-six aircraft (FY94 budget) to be delivered in 1995-1996. The latest audited cost data that can be used in the negotiations ends in 1990. Since MDA-E has undertaken most of its environmental initiatives since 1990, these historical cost data are not a good basis for determining MDA-E's environmental costs.

In addition, accounting for and negotiating environmental costs is complex. Costs incurred when the Government acts in its sovereign capacity are not recoverable. MDA-E is obligated to meet the terms of its government contracts when EPA issues new regulations--even if the regulations substantially increase the cost of performance. On the other hand, costs incurred by MDA-E for meeting environmental requirements imposed through contract changes are fully recoverable. To help MDA-E both plan and negotiate, EA is leading a forward pricing study to determine what the future level of environmental expenditures will be and how to incorporate them into business decisions and contracts.

Another problem area has been resources to make changes to government-owned technical documentation including design and production documents and technical

manuals. Ozone depleting chemical (ODC) elimination is a good example of this. No military program at MDA-E has yet been funded to begin making the needed changes. Thus, even though many of the changes that must be made have no outstanding technical issues, no funding for the paper work is available. In preparing proposals for the Government on ODC elimination, MDA-E has discovered that the cost to change the program technical documentation far exceeds the costs of finding and implementing the changes. A key finding from this effort is that technical documentation systems must be redesigned to reduce the costs associated with making changes. A similar lack of government funding is having an impact on P&W.

On P&W's F119 program, a lack of government funding to qualify "greener" materials and processes for use in standard procedures is causing new technical data to be written that call for the use of chemicals the Air Force is working to eliminate. The standard procedures are used to maintain and repair all P&W engines in all the services; however, none of the individual programs wants to pay for qualifying new materials and processes that benefit all engines. The Air Force's guidance on replacing P-D-680 is a good example.

The materials engineering organization at San Antonio Air Logistics Center (SA-ALC) advised P&W to,

> . . .consider the use of MIL-C-87937. This is a specification for a biodegradable, water based cleaner. This is NOT a drop in replacement for P-D-680, which is a petroleum based dry cleaning solvent. The use of MIL-C-87937 requires totally different procedures. Because it is an aqueous cleaner, it requires rinsing and drying steps after cleaning. In addition, aqueous cleaners cannot be used on certain metals which are highly susceptible to flash rusting. . .
>
> . . . The disposal of P-D-680 is environmentally difficult. In many instances, the P-D-680 must be either burned or be disposed of as waste oil. This can incur significant costs to the AF. MIL-C-87937 contains biodegradability requirements. In many instances, the local municipal treatment plant can biodegrade the MIL-C-87937 cleaners. This allows the AF to incur significant savings. . .

> The replacement of P-D-680 Types I, II, and III with MIL-C-87937 require that the responsible engineer (AF and contractor) conduct a feasibility study because of the different chemical and procedural changes required. . .[79]

The letter does not provide the results of any government conducted materials testing nor does it identify a source of funding for conducting the needed tests or for funding the staff hours needed to write the technical reports that must be submitted to the government's material engineers for approval. In addition, none of P&W's existing contracts provide funding for this type of activity. As a result, P&W is writing engine maintenance technical data that directly conflicts with Air Force pollution prevention goals.

At LASC, resources for pollution prevention are constrained both within the F-22 program and company wide. At a time of declining defense budgets, the F-22 and other systems must be affordable. The program faces higher unit costs due to a declining requirement for the total number of aircraft to be built and because of increasing overhead costs.[80] As discussed at MDA-E, environmental costs can have a substantial impact on overhead cost.

In addition to overhead costs, direct costs are also an issue. For example, direct costs are impacting pollution prevention implementation on the F-22's landing gear. A specification for a cadmium plated surface finish on landing gear parts was developed during the demonstration-validation (Dem/Val) phase of the program and approved by the Air Force. The landing gear for the Dem/Val prototype aircraft were manufactured by the Menasco Aerosystems Division of Coltec Industries. Shortly after Lockheed was awarded

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[79]Captain Peter Poon, letter to SA-ALC/TILTR, "Alternatives or Replacement for P-D-680," (Kelly AFB, TX: SA-ALC/TIESM, 7 April 1993).

[80]Due to the overall decline in the value of military contracts, contractor general overhead costs are a significant problem for the F-22 and other acquisition programs that survive the budget ax. As the defense business base declines in a company, the level of overhead must decline commensurately, or overhead costs for the remaining programs will climb. These cost are then passed on to the government under the cost plus type contracts used on most development contracts, including the F-22.

the EMD contract, a subcontract was awarded to Menasco to produce landing gear for the program using the baseline finish.

Later, after EMD was underway, the Air Force supplied Lockheed with its target list of chemicals for reduction and cadmium is one of the chemicals on the list. The principle alternative to cadmium plating is ion vapor deposition (IVD) of aluminum. Even though IVD aluminum is also an approved finish, Manasco does not have the capability to apply IVD aluminum in-house. Manasco does have the capability to apply cadmium plating.[81] Directing Manasco to replace cadmium plating with IVD aluminum would require a contract change and would result in both cost and schedule impacts. Because of this, neither LASC nor the Air Force has been willing to direct that the switch be made.

One area where facilities are an issue is at government-owned, contractor-operated plants. Since the major facilities at LFWC are part of Air Force Plant (AFP) 4, the government must funds all capital projects under the terms of the facility contract between the Air Force and Lockheed. This means LFWC must deal with a lengthy multi-year programming and budgeting system that in recent years has only approved environmental projects that are critical for compliance.[82] Thus, pollution prevention efforts that require facility modifications are nearly impossible to accomplish.

The government does not provide government-owned plant equipment. Thus, changes to production processes can either be funded directly by the F-16 program office or be done with company funds and charged to overhead. With the end of F-16 production potentially in sight, convincing management to invest company funds has been

[81] Arline Denny, letter to T. Grady, F-22 System Program Office, "Cadmium Plating of F-22 Landing Gear." (Marietta, GA: Lockheed Aeronautical System Company, 1 February 1993).

[82] There are many active Air Force funded compliance projects at AFP-4. For example, the Central System for Control of VOC Emissions, a $2.7 million effort, is nearly complete. A $600,000 closed loop cooling system will be completed in 1994. A $3.0 million project to replace vapor degreasers will also be completed in 1994. A multi-year effort to replace and upgrade underground tanks is continuing. A $1.2 million design effort on a new industrial waste treatment facility is in progress. There are also a number of smaller compliance projects in progress. In all, there are over 15 active projects representing approximately $38 million in construction costs.

difficult, but not impossible. ERM's metrics clearly show they have been successful in obtaining resources. Since 1984, over 35 Zero Discharge projects have been implemented.[83] In addition, interviews with the LFWC staff indicate that they believe there is more support for funding environmental costs by Lockheed than was the case at General Dynamics.

5.4.3.2 Staffing

At MDA-E, the staffing in the core environmental functions has more than doubled over the past several years while the staffing available within the programs has not substantially changed. Unlike the core employees that are charged to overhead, program employees are directly paid for under the program contracts. Getting resources for additional program employees to work environmental issues has been more difficult, but there has been some progress.

The most recent T-45 logistic support contract includes a number of environmental requirements. MDA-E's estimated cost for meeting the requirements included a level of effort consisting of five full time employees for a twenty-seven month performance period. It appears the F/A-18 program may also get some help, but the prospects are not good on the F-15 with U.S. production coming to an end.

At Lockheed, the simultaneous declines in the defense budget and in orders for new aircraft from the airlines, have caused corporate staffs to be reduced. So far, LASC's environmental staff has not been cut (it has held at around forty environmental specialists), but getting additional people to work on pollution prevention has been difficult. A full-time pollution prevention coordinator was being hired at the time of the site visit.

Prior to this at both LASC and at P&W's Government Engines Space Propulsion (GESP) unit, the only full time pollution prevention staff were the hazardous materials

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[83]McKee and Evanoff, 180.

program managers assigned to the F-22 and to the F119. In both companies, this lack of staff has seriously hindered the integration and coordination of pollution prevention efforts.

At LFWC, additional staffing for pollution prevention efforts has been difficult to obtain. As in the rest of the aerospace industry, LFWC has been reducing its work force. As recently as 1991, LFWC employed 32,000 people. By the end of 1994, employment will probably fall to around 10,000, a reduction of almost 70 percent. Of this total, only about 1200 are employed on the F-22 program. This has made it impossible to expand the ERM staff to meet the demands of the 1990 Clean Air Act Amendments or to undertake additional pollution prevention activities. On the other hand, no one in ERM has been let go despite the massive reductions.

5.4.3.3 Resource Summary

Resource constraints present one of the greatest challenges to pollution prevention implementation. "Without them, policies that exist on paper are not the same policies that are carried out in practice. Slippage occurs."[84] In looking at public policy implementation in the government, Edwards was surprised to find that staffs are often too small to be able to effectively implement the policies for which they have been assigned responsibility. With the exception of MDA-E, this is probably the case in the companies studied. Environmental staffing has not increased over the past several years even though new compliance requirements continue to require attention, and at the same time, major pollution prevention efforts have been undertaken.

The compliance portion of the environmental task continues to grow and it must be done. Since environmental staffs have not grown, this usually means that pollution prevention activities are delayed. While the companies have all down-sized in the last two

[84]Edwards, 78.

years, very little reduction in the environmental compliance work load is realized until production processes are completely eliminated. In some cases, down sizing causes more problems. At GESP, the wastewater treatment facilities were designed for much larger flow rates than currently exist. This causes continuing operational difficulties at the plant in meeting discharge standards.

MDA-E's success is largely due to the separation of the day-to-day compliance tasks from strategic planning and pollution prevention. Other examples of this type of separation are the hazardous materials program managers on the F-22 and F119 programs. As program employees, they are able to devote their time to pollution prevention without having day-to-day environmental compliance responsibilities.

Corporate funding for pollution prevention implementation has been good at all the companies. The greater challenge is to get government program managers to fund the environmental costs associated with the government's pollution prevention objectives. A key step in the right direction is the new Air Force acquisition policy on pollution prevention which states:

> The Chief of Staff and the Secretary of the Air Force cosigned two landmark environmental policies concerning pollution prevention and Ozone Depleting Chemicals (ODCs) on 7 Jan 93. On 3 Aug. 93 President Clinton signed Executive Order 12856 that requires all Federal Agencies to have pollution prevention programs working to significantly reduce the use of hazardous materials. . .
>
> . . .The entire acquisition community shall implement these policies. . . Program Management Directives shall be amended at the next opportunity. The funds for implementation must come from the normal budgeting process, and will require program restructuring to accomplish this task within existing program budgets. . .[85]

This policy comes after several years of internal conflict over how to pay for pollution prevention and represents the first serious effort in the Air Force to match acquisition program funding with the Air Force's pollution prevention objectives.

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[85]Druylin, 2.

According to the policy memorandum, programs will have to "restructure" and fund pollution prevention out of their existing budgets. This means giving something else up and may involve purchasing fewer systems, relaxing other requirements, or stretching the program schedule with the hope of getting more funding later. Whatever option each program selects, the policy should eventually help to correct the current imbalance between government objectives and funding that industry is struggling to overcome.

5.4.4 Dispositions

Research on policy implementation has shown that the predisposition of the implementers has sometimes been a key factor in determining whether a policy will succeed or fail. Edwards believes that predisposition is important since,

> Many policies fall within a "zone of indifference." These policies will probably be implemented faithfully because implementers do not have strong feelings about them. Other policies, however, will be in direct conflict with the policy views or personal or organizational interests of implementers. When people are asked to execute orders with which they do not agree, inevitable slippage occurs between policy decisions and performance.[86]

Van Meter and Van Horn suggest that implementers may fail to execute policies faithfully because they reject the goals contained in them. Rejection of a policy's goals can occur for a variety of reasons: they may offend implementer's personal value systems, extraorganizational loyalties, sense of self-interest, or existing and preferred relationships. Van Meter and Van Horn also believe that, at minimum, it would seem that shared attitudes make implementation easier.

Van Meter and Van Horn[87] conclude that three elements of the implementers'' dispositions may affect their ability and willingness to carry out a policy: 1) their cognition

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[86]Edwards III, Implementing Public Policy, 90.

[87]Donald S. Van Meter and Carl E. Van Horn, "The Policy Implementation Process: A Conceptual Framework," Administration & Society 6, no. 4 (February 1975): 472.

(comprehension, understanding) of the policy, 2) the direction of their response toward it (acceptance, neutrality, rejection), and 3) the intensity of that response.

The first element, cognition, was evaluated during the interviews conducted at each company. The second element, the direction of disposition, and the third element, the intensity of disposition, were evaluated using a questionnaire as well as in the interviews.

5.4.4.1 Questionnaire

The purpose of the questionnaire was to provide an indication, during the site visits, of whether defense contractor employees that implement Department of Defense (DoD), Air Force, and company pollution prevention policies have significant negative predispositions toward these policies. The research hypothesis was that implementator's accept the policy or are neutral toward it.

Based on prior visits to Lockheed Aeronautical Systems Company, The Boeing Company, and Texas Instruments, worker predisposition toward the environment did not appear to be a problem in the aerospace industry. Thus, the research hypothesis was that attitudes toward the environment are the same for defense industry workers and the United States population. The alternative is that attitudes among defense workers on environmental issues are different than the U.S. population.

H_0: Environmental attitudes in defense workers = Environmental attitudes in the population
H_a: Environmental attitudes in defense workers $\neq$ Environmental attitudes in the population

To test this hypothesis a questionnaire was constructed using a number of general questions on environmental issues where national data was available. These questions were used to determine if the subjects in this study have significantly different opinions and attitudes on current environmental issues that the US population as a whole. In addition to the general questions, a number of new questions specific to pollution

prevention implementation were used. Overall, the questionnaire consisted of a total of 27 questions and contained questions on five general topics:

1. Environmentalism
2. Environmental behavior
3. Environmental concern
4. Environmental performance
5. Pollution prevention.

In addition, the questions covered three categories of responses: attitudes--what people say they want, beliefs--what people say they think is true, and behavior--what people say they do. Twenty of the 27 questions were taken from national surveys on the environment. The responses to these twenty questions were used to evaluate the research hypothesis. The remaining seven questions were used to gather specific information on company environmental policies and on pollution prevention.

A summary of the questions included in the questionnaire is shown in Table 5.16. The left hand column contains the question number and indicates the order the question appears in the questionnaire. The middle column contains the question categories in bold type followed a summary of each question's text. Finally, the right hand column indicates whether the question has national data for comparison.

5.4.4.2 Data Analysis Methods

The data were analyzed to determine if the responses in each case study differ from the national data. Since the responses to all questions involve categorical data, non-parametric test statistics were used. For questions with dichotomous answers, Fisher's exact test was used.[88] For questions with ordered ordinal responses, a mean score statistic,[89] calculated with standardized midranks[90] was used.

[88]Gary G. Kock and Suzanne Edwards, "Clinical Efficacy Trials with Categorical Data," Chapter 9 in Biopharmaceutical Statistics for Drug Development, ed. Karl E. Peace, (New York, NY: Marcel Dekker, 1988), 409.

[89]Ibid., 411-413.

Quest	Question Category and Summary of Question Text	National Data
	Environmentalism	
4a	Do you consider yourself to be an environmentalist	Yes
4b	If yes, do you consider yourself a strong environmentalist	Yes
14	There is not much one person can do to help the environment	Yes
15	People involved in groups concerned about environmental issues--Are these people are reasonable people, or are most of them extremists	Yes
16	Protecting the environment is so important that requirements cannot be too high.	Yes
17	We must protect the environment even if it means increased government spending and higher taxes	Yes
18	We must protect the environment even if it means jobs in your community are lost	Yes
	Environmental Behavior	
3	How often do you have conversations with other people about the environment	Yes
21	Boycotted a company's products because of its record on the environment	Yes
22	Specifically avoided buying a product because it was not recyclable	Yes
23	Voluntarily recycled newspapers, glass, aluminum, motor oil, or other items	Yes
24	Did volunteer work for an environmental, conservation, or wildlife preservation group	Yes
25	Contributed to an environmental group	Yes
	Environmental Concern	
1	Is the condition of the environment getting better, worse, or is it staying the same	Yes
2	Overall, how worried are you about the condition of the environment	Yes
5	Do you think the government today is too worried about the environment, not worried enough, or expresses about the right amount of concern	Yes
6	Do you think business and industry today is too worried about the environment, not worried enough, or expresses about the right amount of concern	Yes
7	Do you think your company is too worried about the environment, not worried enough, or expresses about the right amount of concern	No
	Environmental Performance	
8	In keeping the environment clean, how would you rate the federal government	Yes
9	In general, how would you rate U.S. corporations for keeping the environment clean	Yes
10	When it comes to the environment, how would you rate yourself	Yes
	Pollution Prevention	
11	How much opportunity do you have to prevent pollution in your community	No
12	How much opportunity do you have to prevent pollution in your company	No
13	In your company, efforts to prevent pollution are strongly supported by management	No
19	In your company, too much time is spent on environmental issues	No
20	On this project, product quality includes reducing and controlling pollution.	No
	Demographics	
26	What is your occupation	No

Table 5.16. Summary of Questionnaire Questions

[90] In the SAS procedure FREQ, standardized midrank scores are referred to as modified ridits.

In addition, the data were also analyzed across case studies looking for a significant trend where each case was treated as a separate strata. Dichotomous questions were evaluated using the Mantel-Haenszel chi-square test.[91] Questions with ordered data were again evaluated using a mean score statistic.

In this study, the results for a case were considered to be meaningfully different from the national data if five or more of the twenty questions with national data, had results that were statistically different from the national data.

The sample sizes for the historical surveys are shown below:

New York Times/CBS News	1,515
Gallup	1,223
USA Today	850

Since the USA Today survey had the smallest sample size of 850, this figure was used to check the required sample size for the survey. The method for calculating unequal sample sizes was taken from Fliess[92], where: sample size - n_1 subjects in Group 1 (historical surveys) and $n_2 = kn_1$ in Group 2 (planned surveys). The test hypothesis is: H_o: $\pi_1 = \pi_2$ against alternative H_a : $(\pi_1 - \pi_2) = 0$ (two sided), where:α = Type I error = 0.10 and β = Type II error = 0.75. The complete calculation is shown in Appendix F.

The required sample size calculated for the historical data using the Fliess equations is approximately 700. Since the smallest historical survey has 850 respondents, the national polls are large enough to support a Mantel-Haenszel test to compare proportions. The required sample size for each subunit to be studied is approximately 35. Thus, a sample size of approximately 35 is needed to test for a difference of 10% between the historical polls and data from each contractor to be studied, where $\alpha = 0.1$ and $\beta = 0.75$.

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[91]Kock and Edwards, 416-417.

[92]Joseph L. Fleiss, Statistical Methods for Rates and Proportions, 2nd ed.. (New York: John Wiley. 1981), 44-46.

5.4.4.3 Questionnaire Results

The questionnaire was administered at each site and a total of 261 responses were obtained. The distribution among cases and types of workers is shown in Table 5.17.

Frequency Row Pct.	Manager	Engineer	Professional	Admin or Clerical	Skilled / Foreman	Other	Total
LASC	8 12.5%	46 71.8%	7 10.9%	3 4.6%	0 0.0%	0 0.0%	64
LFWC	5 14.7%	4 11.8%	14 41.2%	3 8.8%	7 20.6%	1 2.9%	34
MDA-E	23 25.3%	45 49.5%	14 15.4%	9 9.9%	0 0.0%	1 1.1%	92
P&W	7 9.9%	47 66.1%	5 7.0%	2 2.8%	4 5.6%	2 8.5%	71

Table 5.17. Questionnaire Sample Size and Distribution

The largest sample, consisting of 92 responses, was obtained at MDA-E. The smallest sample contains 34 responses from LFWC. This is right at the minimum sample size needed for hypothesis testing. With the exception of LFWC, the sample data come mostly from workers that identify themselves as managers, engineers, or other professionals. A copy of the questionnaire and a complete listing of the data and test statistics are provided in Appendix F.

An initial analysis of the data indicates that the hypothesis of no difference between company workers and national survey results should be rejected in every case when the data are evaluated using the appropriate test statistics at the 0.10 significance level. LFWC's respondents differed from the national data on seven questions, P&W's on eight questions, LASC's on nine questions, and MDA-E's on twelve questions. Overall, looking across strata, a significant trend differing from the national data was identified on eleven questions.

Although the initial results look highly significant, they must be viewed with caution because of three sources of potential bias in the results. First, the data do not represent a random sample at any of the sites. A sample of convenience was used at each location. Questionnaires were distributed to much larger numbers of professional-level employees than to hourly workers. Second, the questionnaires were distributed in the work place while the national data was collected using telephone interviews. This biases the definition of "environment," since environment is not defined in either the national surveys or the questionnaire (it may mean the local environment, national environment, global environment, etc.). On the questionnaire, respondents appear to assume that several questions are referring to the environment in and around the work place. This bias would not occur in the telephone surveys. Finally, there is a bias toward professional and management employees among the respondents. Overall, 86 percent of the 261 total respondents identified themselves as managers, engineers, or other professionals.

Table 5.18 shows the rotated factor matrix from a factor analysis of the data. Eight factors were extracted in the principal-components analysis using a minimum eigenvalue of 1.0 for significant factors. The factor matrix was then rotated using orthogonal rotation to produce statistically uncorrelated factors. The eight factors extracted explain 56.7 percent of the variance in the data. Strongly related questions are shown in bold face type in Table 5.18. Note that of the eight factors, only the first six factors have more than one question with a factor loading greater than 0.6. Factor loadings describe the correlation between the factors emerging from the factor analysis (listed at the top of Table 5.18) and the original variables (list vertically on the left side).

The six significant factors identified in Table 5.18, are labeled and described in Table 5.19. The factors identify underlying characteristics, that hopefully, are conceptually meaningful. In this analysis, all six factors are meaningful. In addition, the highly loaded questions for each factor come from only one of the five general topics that were listed in Section 5.4.4.1.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
1	.13435	-.00672	-.12133	.18976	.15229	-.16917	.55778	.00006
2	.37003	.18429	-.19009	.41888	.04623	.03119	.03757	.37859
3	.07405	.05577	.08460	-.00568	.02131	.09296	-.14153	**.81236**
4a	.13153	**.91505**	.11823	.06612	.07550	.01833	-.01955	.02808
4b	-.09813	**-.90640**	.01003	-.03296	.00237	-.05470	.02290	-.06365
5	.07843	-.00709	.05641	**.75675**	.21389	-.14956	.16560	.03803
6	-.09112	.02406	-.16740	**.74044**	.12662	-.17556	-.08858	-.13065
7	.02612	.08659	-.05500	.52873	.00051	.38644	.05610	.16011
8	.00976	-.12237	.54808	.03776	.02416	.21315	-.18927	-.39506
9	-.00451	-.02034	**.71107**	-.18905	-.25543	.09337	.04122	.02730
10	.04183	.24756	**.67010**	-.04453	.03728	-.07127	-.09468	.12096
11	-.07552	.11969	.32127	.07774	[illegible]798	.08502	-.47222	.22738
12	-.14184	-.00035	.34754	-.08432	.18341	.45156	-.35636	.22676
13	-.03629	.20120	.18244	-.09240	.00903	**.73877**	-.08168	-.11504
14	-.32031	.01810	.05206	-.05561	.04274	-.00664	**.65222**	-.00362
15	.12172	-.06227	.17824	.21091	.07386	.32121	.35003	.37106
16	[illegible]2	-.04709	-.00621	-.01522	**.63623**	-.16871	.28241	-.22478
17	.08669	.02372	-.03605	.17636	**.73635**	.11857	.03697	.08153
18	.00359	.05528	-.04813	.12600	**.64276**	.03560	-.09503	.08671
19	.22570	-.12989	.34318	.05098	.14702	.35264	.21388	.18891
20	.07061	-.05867	-.07861	-.06545	-.02823	**.65812**	-.09900	.09428
21	**.61041**	.07783	.00295	-.11148	.30145	.01586	-.02368	.16897
22	**.60420**	.25973	.17822	.19648	-.05844	.06875	-.07092	.05624
23	**.70785**	-.02976	-.02539	.06976	-.13631	-.00865	-.09076	-.13775
24	**.67310**	-.04259	.10950	-.03706	.04018	-.05499	.06206	.10894
25	**.61651**	.17974	-.24412	-.02396	.22689	.13084	.08845	-.00627

Table 5.18. Rotated Factor Matrix

This helps to validate that questions selected from the national surveys for each topic address one or more common characteristics of the topic. In presenting the results of the questionnaire, each question with be briefly examined and questions shown to be related in the factor analysis will be presented at the same time.

Question 1, shown in Table 5.20, asks for the respondent's opinion on the condition of the environment. While the national data show that people believe the condition of the environment is getting worse, respondents in the companies believe that it is staying the same or getting better. While this answer is different from the national data, it can be seen as a "positive" result if the respondents are interpreting the question in terms of the environment around their plant site as impacted by the company.[93]

[93]The probability values shown in the table represent the probability of obtaining a value of the test statistic (in Table 5.20, the row mean score statistic) that is greater than the observed value. The probability is a measure of the strength of the evidence against the null hypothesis. The smaller the value, the stronger the evidence for rejecting the null hypothesis. Probability values are shown to three decimal places. Thus, a value of 0.000 means that the probability is less than 0.000. Since a significance level of

#	Factor Label	Topic	Factor Description
1	Personal Environmental Behavior	Environmental Behavior	Includes actions that the person, or member of the person's household, has done in recent years such as boycotting products, recycling, performing volunteer work for environmental groups, and contributing to environmental causes.
2	Environmental Identity	Environmentalism	Does the person believe that they are an environmentalist, and if so, do they consider themselves to be a strong environmentalist.
3	Environmental Protection Effectiveness	Environmental Performance	In rating how well the environment being kept clean, respondent's rating of themselves and for U.S corporations are related. This indicates that the respondents personal and professional views are related. In addition, note that the factor loading on Question 8, rating the Federal government, was just below 0.60 at 0.54. This suggests that all three ratings are governed by an underlying common perception concern the effectiveness of environmental protection efforts.
4	Institutional Worry	Environmental Concern	Concerns how worried government, and business and industry are concerning the environment. The responses indicate that in general, big institutions, worry too much about environmental issues.
5	Personal Consequences of Tough Regulations	Environmentalism	Relates paying higher taxes, losing jobs in the community, and setting environmental requirements and standards with high costs. Potential personal consequences that result from tougher regulations are related.
6	Pollution Prevention Opportunities at Work	Pollution Prevention	Includes the opportunity to prevent pollution in the company and reducing pollution on the project.

Table 5.19. Environmental Factors

Question 1 - Is the condition of the environment?

	Getting Worse	Staying the same	Getting better	Don't Know	Row Mean Score (Probability)
USA Today	64.7%	25.8%	6.8%	2.5%	
LASC	21.8%	31.2%	45.3%	1.5%	0.000
LFWC	23.5%	50.0%	20.6%	5.9%	0.000
MDA-E	22.8%	34.8%	40.2%	2.2%	0.000
P&W	29.5%	23.9%	46.4%	0.0%	0.000

Table 5.20. Questionnaire Data for Question 1

0.10 has been selected, the data from all four companies indicate that the null hypothesis should be rejected. This means that the attitudes of the company workers are statistically different from the attitudes found in the national sample.

Question 2 asks how worried the respondent is about the environment. The most common response in both the national data and the industry was, "somewhat worried." Question 3 asks how often the respondent has conversations about the environment. The most common answers were once a week or once a month. For both Questions 2 and 3, the company responses were similar to the national data.

Questions 4a and 4b are highly correlated in Factor 2. Both questions address whether respondents label themselves as environmentalists. The data are shown in Table 5.21 and Table 5.22. In Question 4, significantly fewer LASC and MDA-E respondents consider themselves environmentalists, and overall, the trend is significantly different for the industry.

Question 4a - Do you consider yourself to be an environmentalist?

	Yes	No	Don't Know	Fisher's Test (Probability)
Gallup	72.9%	24.0%	3.0%	
LASC	50.0%	45.3%	4.6%	0.000
LFWC	61.8%	32.4%	5.9%	0.218
MDA-E	54.9%	40.7%	4.4%	0.000
P&W	63.3%	29.5%	7.0%	0.193

Table 5.21. Questionnaire Data for Question 4a

Question 4b - If you consider yourself an environmentalist, are you a strong environmentalist?

	Yes	No	Don't Know	Fisher's Test (Probability)
Gallup	47.9%	52.1%	0.0%	
LASC	29.0%	58.1%	12.9%	0.171
LFWC	14.3%	76.2%	9.5%	0.000
MDA-E	18.4%	65.3%	16.3%	0.001
P&W	13.9%	81.4%	4.6%	0.000

Table 5.22. Questionnaire Data for Question 4b

This seems to imply a negative direction in environmental dispositions as compared to the national data. Answers to Question 4b seem to confirm this trend where the respondents at three out of four companies were significantly less likely to consider themselves strong environmentalists than in the national survey.

A partial explanation for the differences seen in Questions 4a and 4b may be provided in the answers to Question 15 where respondents were asked if people in environmental groups are most often reasonable or if they are extremists. As seen in the data shown in Table 5.23, respondents in two of the four companies believed that people in environmental groups are significantly less likely to be reasonable indicating a negative connotation with being associated with an environmental group.

Question 15 - People in environmental groups are most often:

	Reasonable	Extremist	Don't Know	Fisher's Test (Probability)
CBS News	63.8%	28.7%	7.4%	
LASC	50.0%	34.3%	15.6%	0.137
LFWC	55.9%	32.4%	11.8%	0.551
MDA-E	43.8%	39.3%	16.9%	0.000
P&W	32.3%	46.4%	21.1%	0.000

Table 5.23. Questionnaire Data for Question 15

Questions 5 asks for the respondent's opinion on whether the government worries too much or too little about the environment. Question 6 addresses the same issue for business and industry, and Question 7 addresses the issue for their company. Responses are shown in Table 5.24, Table 5.25, and Table 5.26.

For Questions 5 and 6, respondents believe that both the government, and business and industry, worry too much about the environment while in the national data people believe the opposite. This relationship can also be seen in the factor loading for Factor 4 which indicates that Questions 5 and 6 are measuring a common characteristic.

Question 5 - Do you think the government today is too worried about the environment, not worried enough, or expresses about the right amount of concern about the environment?

	Not Enough	About Right	Too Much	Don't Know	Row Mean Score (Probability)
Gallup	74.9%	17.9%	3.0%	4.0%	
LASC	29.6%	9.3%	56.2%	4.6%	0.000
LFWC	50.0%	11.8%	38.2%	0.0%	0.000
MDA-E	21.7%	14.1%	56.5%	6.5%	0.000
P&W	23.9%	15.4%	52.1%	8.4%	0.000

Table 5.24. Questionnaire Data for Question 5

Question 6 - Do you think business and industry today is too worried about the environment, not worried enough, or expresses about the right amount of concern about the environment?

	Not Enough	About Right	Too Much	Don't Know	Row Mean Score (Probability)
Gallup	83.2%	10.8%	2.9%	2.9%	
LASC	20.3%	6.2%	70.3%	3.1%	0.000
LFWC	32.4%	0.0%	64.7%	2.9%	0.000
MDA-E	19.6%	2.2%	75.0%	2.2%	0.000
P&W	9.8%	2.8%	78.8%	8.4%	0.000

Table 5.25. Questionnaire Data for Question 6

Question 7 - Do you think your company is too worried about the environment, not worried enough, or expresses about the right amount of concern about the environment?

	Not Enough	About Right	Too Much	Don't Know
LASC	46.8%	6.2%	37.5%	9.3%
LFWC	76.5%	5.9%	17.6%	0.0%
MDA-E	58.7%	4.3%	29.3%	7.6%
P&W	63.3%	4.2%	21.1%	11.2%

Table 5.26. Questionnaire Data for Question 7

The responses to Questions 5 and 6 are consistent with the respondents' answers to Question 1 where they believe the condition of the environment is getting better while nationally, people believe it is getting worse.

Interestingly, on Question 7 the respondents reverse their answers. While respondents believe that in general, society (government, business, and industry) is too worried about the environment, they believe that their company is not worried enough about the environment. This reply was consistent for all companies and no statistically significant trend between companies was observed. Once again, this result can be seen as a positive indication. Given that the respondents seem to believe that the condition of the environment is not as bad as people nationally think and that too much time is spent worrying about it, they still believe that their companies should be more concerned for the environment--a positive sign for pollution prevention.

Questions 8, 9, and 10 address how different groups rate in keeping the environment clean: Question 8 considers the Federal government, Question 9 considers US corporations, and Question 10 asks respondents to rate themselves. In Factor 3, Questions 9 and 10 both display high factor loadings indicating that these questions are closely related. With one exception, responses to these questions were consistent with the national data. The exception was at LASC where more respondents rated the Federal government poor rather than fair as in the national data or at the other companies. Overall, when asked to rate environmental performance, the respondents' opinions look very much like those of people nationally. Thus, respondents seem to make a distinction, not made by the public in general, between what they perceive as actual performance and the amount of time spent talking and worrying about environmental problems. Based on the interviews, this result seems to illustrate the respondents' frustration over spending too much time talking and worrying about environmental problems instead of taking concrete actions that they recognize as being needed.

Questions 11 (Table 5.27) and 12 (Table 5.28) ask respondents about the opportunities they have to prevent pollution in their community and in their company. In their community, the respondent's most common reply was that they have "only some" opportunity. When asked the same question about their company, the responses shifted

toward "hardly any" indicating a belief that they have less opportunities to prevent pollution at work than at home. Also note the increase at LASC, MDA-E, and P&W in the percentage of respondents that believe they have no opportunity to prevent pollution at their company as opposed to in their community. A significant exception to this trend occurred in the responses at LFWC, however. At LFWC there is little difference in the responses to Questions 11 and 12.

Question 11 -How much opportunity do you feel you have to prevent pollution in your community?

	Great Deal	Only Some	Hardly Any	None	Don't Know
LASC	14.1%	42.1%	40.6%	0.0%	3.1%
LFWC	17.6%	61.8%	20.6%	0.0%	0.0%
MDA-E	8.7%	60.9%	29.3%	1.1%	0.0%
P&W	7.0%	70.4%	15.4%	2.8%	4.2%

Table 5.27. Questionnaire Data for Question 11

Question 12 -How much opportunity do you feel you have to prevent pollution in your company?

	Great Deal	Only Some	Hardly Any	None	Don't Know
LASC	10.9%	35.9%	40.6%	10.9%	1.5%
LFWC	23.5%	50.0%	23.5%	0.0%	2.9%
MDA-E	4.3%	35.9%	50.0%	8.7%	1.1%
P&W	9.8%	35.2%	42.2%	11.2%	1.4%

Table 5.28. Questionnaire Data for Question 12

Question 13 (Table 5.29) asks if the respondent's company strongly supports efforts to prevent pollution. Well over half of all respondents agree that management supports pollution prevention and statistically, no significant trend was found between the responses at the different companies. Question 20 (Table 5.30) asks a related question on whether product quality includes reducing pollution on their project. The relationship between Questions 13 and 20 is confirmed by the factor loadings in Factor 6. Many

respondents answered "don't know" to Question 20 question because they work in core functional areas that are not project or program specific. Among those that did answer "yes" or "no," there is a statistically significantly difference in the answers at the different companies.

In particular, the MDA-E employees do not believe that their company supports pollution prevention as in as strongly as is the case at the other companies. This finding is consistent with the modest four percent reduction in releases of the EPA 33/50 Program chemicals that was reported in section 5.2.3 and indicates that MDA-E's new Environmental Assurance function has yet to have a significant impact on environmental activities.

Question 13 - In your company, efforts to prevent pollution are strongly supported by management:

	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	Don't Know
LASC	29.6%	42.1%	9.3%	10.9%	7.8%
LFWC	38.2%	50.0%	8.8%	0.0%	2.9%
MDA-E	20.7%	47.8%	16.3%	5.4%	9.8%
P&W	25.3%	47.8%	9.8%	4.2%	12.6%

Table 5.29. Questionnaire Data for Question 13

Question 20 - On this project, product quality includes reducing and controlling pollution:

	Yes	No	Don't Know
LASC	65.6%	10.9%	23.4%
LFWC	79.4%	2.9%	17.6%
MDA-E	47.3%	25.3%	27.5%
P&W	53.5%	19.7%	26.7%

Table 5.30. Questionnaire Data for Question 20

Question 14 addresses how much one person can do to help the environment. Respondents at LASC, LFWC, and P&W answered this question similarly to people

nationally, while respondents at MDA-E did not believe that one person could make much of a difference.

Question 14 - There is not much one person can do to help the environment. Do you:

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Row Mean Score (Probability)
USA Today	13.8%	20.4%	26.5%	36.5%	
LASC	6.2%	28.1%	37.5%	26.5%	0.518
LFWC	2.9%	38.2%	29.4%	29.4%	0.502
MDA-E	7.7%	35.2%	35.2%	22.0%	0.026
P&W	5.6%	30.9%	39.4%	22.5%	0.232

Table 5.31. Questionnaire Data for Question 14

Factor 5 shows that Questions 16, 17, and 18 are highly related. This relationship should be expected since all of the questions deal with potential consequences of protecting the environment. Question 16 asks respondents if environmental standards can be set too high. Question 17 asks if respondents are willing to protect the environment even if it means higher taxes and Question 18 asks if respondents are willing to protect the environment even if jobs are lost in their community.

Question 16 - Do you agree or disagree with the following statement: Protecting the environment is so important that requirements cannot be too high and continuing environmental improvements must be made regardless of cost.

	Agree	Disagree	Don't Know	Fisher's Test (Probability)
CBS News	76.3%	21.6%	2.0%	
LASC	23.4%	70.3%	6.2%	0.000
LFWC	14.7%	70.6%	14.7%	0.000
MDA-E	30.4%	63.0%	6.5%	0.000
P&W	30.9%	54.9%	14.1%	0.000

Table 5.32. Questionnaire Data for Question 16

Responses to Question 16 were significantly different than the national data in every case. Given the large number of professionals involved in system engineering activities

that responded to the questionnaire this result is not at all surprising since the very essence of the system engineering process involves finding a balanced design compromise from a large set of design criteria. In systems engineering, any criterion can be set impossibly high. Thus, it is not surprising that engineers believe that environmental standards can be set too high.

Answers to Question 17 show that respondents at LASC and MDA-E are less likely to be willing to pay higher taxes to improve the environment than people nationally. In addition the trend across strata was significant.

Question 17- Do you agree or disagree with the following statement: We must protect the environment even if it means increased government spending and higher taxes.

	Agree	Disagree	Don't Know	Fisher's Test (Probability)
CBS News	72.2%	24.7%	4.9%	
LASC	59.3%	37.5%	3.1%	0.039
LFWC	52.9%	26.5%	20.6%	0.383
MDA-E	54.9%	37.4%	7.7%	0.005
P&W	59.1%	32.3%	8.4%	0.113

Table 5.33. Questionnaire Data for Question 17

In Question 18, respondents at three of the four companies indicated that they are willing to protect the environment even if jobs are lost in the community. This result was surprising given the large job losses in the aerospace industry during the past several years. Since the factor analysis shows that Questions 16, 17, and 18 are measuring the same concept, one could conclude that the respondents are somewhat less willing to incur the consequences of protecting the environment than people nationally, but the results of Questions 16, 17, and 18 must be viewed with caution given the special circumstances described above.

Question 18 - Do you agree or disagree with the following statement: We must protect the environment even if it means jobs in your community are lost because of it.

	Agree	Disagree	Don't Know	Fisher's Test (Probability)
CBS News	56.0%	36.0%	7.9%	
LASC	40.6%	42.1%	17.1%	0.088
LFWC	50.0%	32.4%	17.6%	1.000
MDA-E	47.3%	36.3%	16.5%	0.471
P&W	45.1%	35.2%	19.7%	0.491

Table 5.34. Questionnaire Data for Question 18

Question 19 asks if too much time is spent on environment issues in your company. Respondents consistently and overwhelmingly disagreed with this statement as shown in Table 5.35. The perception that more time should be spent on the environment is even stronger (in a positive sense toward the environment) than results obtained in Question 13 where respondents agreed that company management strongly supports efforts to prevent pollution. The answer is also consistent with the results of Question 7 where respondents in every company believe that their company does not worry enough about the environment. Taken together, these three questions provide strong evidence that predisposition toward the environment should not be a concern in implementing pollution prevention.

Question 19 - In your company, too much time is spent on environmental issues.

	Agree	Disagree	Don't Know
LASC	1.5%	78.1%	20.3%
LFWC	2.8%	74.6%	22.5%
MDA-E	2.9%	88.2%	8.8%
P&W	1.1%	81.5%	17.4%

Table 5.35. Questionnaire Data for Question 19

The factor loadings from Questions 21, 22, 23, 24, and 25 are all high in Factor 1. These questions form a set on the questionnaire and are all part of the environmental

behavior category. Each question in the set is based on the common lead-in question: "Which of the following things, if any, have you or other household members done in recent years to try to improve the quality of the environment?"

Question 21 - Boycotted a company's products because of its record on the environment?
Question 22 - Specifically avoided buying a product because it was not recyclable?
Question 23 - Voluntarily recycled newspapers, glass, aluminum, motor oil, or other items?
Question 24 - Did volunteer work for an environmental, conservation, or wildlife preservation group?

Question	21			22			23			24		
	Yes	No	isher's Test	Yes	No	Fisher's Test	Yes	No	Fisher's Test	Yes	No	Fisher's Test
Gallup	27.9%	72.0%		62.9%	37.0%		85.0%	14.9%		17.9%	82.0%	
LASC	29.6%	70.3%	0.776	42.1%	57.8%	0.001	95.7%	6.2%	0.066	23.4%	76.5%	0.318
LFWC	39.4%	60.6%	0.418	51.5%	48.5%	0.203	97.1%	2.9%	0.049	15.6%	84.4%	1.000
MDA-E	20.7%	79.3%	0.171	51.1%	48.9%	0.032	97.8%	2.2%	0.000	9.8%	90.2%	0.046
P&W	33.8%	66.2%	0.281	46.4%	53.5%	0.000	92.9%	7.1%	0.081	14.1%	85.9%	0.523

Table 5.36. Questionnaire Data for Questions 21, 22, 23, and 24

The responses to Question 21, on boycotting products, are the same as the national survey. For Question 22, on avoiding products because they a not recyclable, responses at LASC, MDA-E, and P&W all differed from the national data in the negative direction with regard to the environment. Question 23, concerning voluntarily recycling efforts, is the only question on the questionnaire where the responses at each company were statistically significant in the direction of being more positive on the environment than the national data. Question 24 asks about volunteer work for environmental groups. Only the responses at MDA-E differ from the national data indicating that less respondents do volunteer work.

For Question 25, on contributing to environmental groups, the responses at each company are similar to the national data. Overall, the data from the questions making up Factor 1 are mixed. This would seem to indicate that the respondents' environmental behaviors are similar to those in the national data.

Question 25 - Contributed to an environmental group, such as the Sierra Club, Greenpeace, the National Audubon Society, or others like these?

	Yes	No	Don't Know	Fisher's Test (Probability)
USA Today	40.0%	58.9%	1.1%	
LASC	45.3%	54.6%	0.0%	0.510
LFWC	32.4%	61.8%	5.9%	0.583
MDA-E	40.2%	59.8%	0.0%	1.000
P&W	33.8%	60.5%	5.6%	0.518

Table 5.37. Questionnaire Data for Question 25

5.4.4.4 Disposition Summary

Using the results from the interviews and the questionnaire, Van Meter and Van Horn's three key elements of implementers' dispositions that impact their ability and willingness to carry out a policy can be assessed. Each element, 1) cognition (comprehension, understanding) of the policy, 2) the direction of implementers' responses toward it (acceptance, neutrality, rejection), and 3) the intensity of the response, is discussed below.

Without exception the interviewees were aware that the company has a pollution prevention policy and could explain at least the portions that directly impacted their jobs. For design engineers this included technical issues and procedures. For others, such as the administrative staff, this may have included only the solid waste recycling program. While this was somewhat surprising, it was not totally unexpected. A review of the company newsletters shows that articles on their environmental programs and accomplishments are run frequently. In addition, posters, signs, and awareness training efforts were common. In discussing company pollution prevention policy, the most common reaction encountered was that the company has a good program, but that it could do more. Based on the wide-spread recognition of the existence and need for pollution prevention programs, cognition of the policy does not seem to be an issue.

The direction of response to the pollution prevention policy is positive, but as demonstrated in the questionnaire data, the respondents have different attitudes and beliefs toward environmental issues than people in national telephone surveys. The respondents' environmental behaviors, as assessed in Questions 3, 21, 22, 23, 24, and 25, seem to track the national survey data reasonably well.

Briefly summarizing the survey data, the respondents believe that the condition of the environment is getting better while people in the national surveys believe it is getting worse. On balance, those answering the believe that government and industry spend too much time worrying about environmental issues. When asked to rate the performance of the government and of industry; however, their opinions track closely with the national samples. The respondents are less like to identify themselves as environmentalists and they believe that environmental standards can be set too high. The respondents' environmental behaviors are similar to those in national surveys. They boycott products and contribute to environmental groups in similar proportions as the national surveys. They recycle more frequently, but do a little less volunteer work. Finally, respondents believe that their companies support pollution prevention efforts and they believe the companies should do more.

In conclusion, based on the survey results and the interviews three points can be made: 1) the employees at each company appear to understand the pollution prevention policies, 2) they accept the policy, or are neutral toward the policy, and 3) they have different views on the environment than found in national samples, but the differences do not include strong negative attitudes about environmental issues. Overall, these results support the view that employees do not display any wide spread negative disposition toward pollution prevention activities that would interfere with implementation of each company's policies.

5.4.5 Decision Making and Management Procedures

The purpose of this section is to describe the decision-making context for pollution prevention in system acquisition programs. This information was gathered during the interviews by asking employees how pollution prevention issues are being addressed in the decision making processes in which they participate. Not surprisingly, the employees' answers match the descriptions found in the weapons acquisition literature closely. The primary difference is the current focus on using concurrent engineering techniques that were not widely used when much of the literature was written.

In the developmental programs studied, most design decisions are made within integrated product teams (IPTs). The goal of the IPT decision making process is to make balanced decisions after considering all competing requirements. Within this process all requirements do not carry equal weight, however.

Interviews with IPT leaders and members suggests that within the air vehicle portion of the F-22 program and in the F119 program, design decisions are often made using a three level priority scheme for the decision making criteria as shown in Table 5.38.

Priority	Decision Criteria
1.	Does it meet contract requirements?
2.	Is it the lightest weight solution? Is it the lowest cost solution?
3.	All other criteria.

Table 5.38 Integrated Product Team - Priorities for Design Decisions

Meeting quantitative contract requirements is the most important criteria. Weight and cost tie for second place in importance behind contract requirements. Although aircraft weight is not subject to a firm contract requirement on the F-22, it is still very important since it directly impacts a host of closely related operational performance requirements.

Within the overall cost criteria, there are several unequal considerations. The most important cost element is contractor's cost on the current contract. On the F-22, this is the engineering and manufacturing development (EMD) contract. This is the cost directly chargeable to the contract and covers the contractor's on-going engineering and testing costs. Second, behind the EMD cost is the design-to-cost for the part or component. This is the "target" average unit cost for producing the item in a production program. Finally, the IPT considers life cycle costs.

Pollution prevention falls into the last category. The F-22 contract requires LASC to operate a hazardous materials program that includes management and reporting requirements, but no quantitative requirements that can be allocated to the IPTs.

5.5 Pollution Prevention Implementation in Acquisition Programs

Pollution prevention implementation in the acquisition programs studied was highly dependent on having a successful facility-based pollution prevention program in the company and a set of design methodologies that include pollution prevention as a feature. The impact of pollution prevention design methodologies is discussed in Chapter 6. The impacts of the facility-based pollution prevention efforts are discussed below.

First, the key features of each program are described. Then, two elements that are important to understanding the company programs, that were not specifically discussed in the implementation contextual factors, are presented: 1) integrating facility-based pollution prevention efforts with acquisition programs and 2) the company environmental record.

5.5.1 Pollution Prevention Program Key Features

5.5.1.1 Lockheed Aeronautical Systems Company

The pollution prevention program at LASC consists of two major thrusts: 1) improving hazardous materials management, and 2) reducing the use of hazardous

materials and the release of wastes. The first thrust, hazardous materials management, includes three major goals:

1. Creating a Hazardous Materials Review Board (HMRB),
2. Controlling the acquisition, movement, storage, and disposal of hazardous materials,
3. Improving the management and flow of information on hazardous materials.

The Hazardous Materials Review Board (HMRB) was created to help LASC comply with acquisition, inventory, safety, transportation, and disposal requirements for hazardous materials. To accomplish this, the HMRB is tasked to, "Administer a program by which hazardous materials used by LASC are reviewed, classified, and approved prior to acquisition."[94] In addition to reviewing and approving which hazardous materials can be used at LASC, the HMRB also defines hazardous material use and management parameters. Use parameters include items such as personal protection equipment, ventilation, and monitoring. Management parameters include pollution prevention considerations such as *elimination, substitution, and consolidation* as well as waste management and disposal.

The second major goal of LASC's hazardous materials management efforts involves controlling the acquisition, movement, storage, and disposal of hazardous materials. The most import aspect of the effort was getting control over who could order what materials. The HMRB contributes to answering what can be ordered. Controlling the purchasing of hazardous materials required discipline in the various purchasing systems.

Another key element in LASC's plan was the creation of a Hazardous Materials Handling and Control section with responsibility for controlling and tracking all hazardous materials from purchase through disposal. The section is within the operations organization. Setting up the section required facility modifications, new equipment, computer support, and manpower. Important improvements introduced by the section

[94]Lockheed Aeronautical Systems Company, "Hazardous Materials Review Board," 1.

include centralized receipt and storage, bar coding and dispensing, same day issue and return of materials, a tracking data base, and responsibility for disposal of unneeded materials and expired shelf life materials.

A third goal in improving hazardous materials management at LASC involves improving the management and distribution of information on hazardous materials. The core of this effort is managing material safety data sheets (MSDSs).

Before the effort began, LASC had 2000 MSDSs on hand. Paper copies were hard to control and maintaining up-to-date information in the work places was impossible. LASC now has over 14,000 MSDSs entered into an electronic data base and are actively working to obtain MSDSs on several thousand more materials for which they do not have a current MSDS. The electronic system consists of a scanned copy of the original that can be called up and viewed as well as key information taken from each MSDS that can be searched and sorted. The system is designed to allow any worker to use any computer terminal in the work place to access any MSDS. This will eliminate the need to maintain paper copies of MSDSs in the shops.

In addition to its major thrust on hazardous materials management, LASC is also actively pursuing pollution prevention in its manufacturing operations. This major thrust includes initiatives in five major areas:

1. EPA 33/50 Program chemicals
2. Volatile Organic Chemicals (VOCs)
3. Hazardous Waste
4. Wastewater
5. Recycling

Oversight of LASC's efforts in these areas is being consolidated in a newly formed Pollution Prevention Committee. Work on each issue is assigned to an integrated product team (IPT) formed specifically to resolve each problem. For example, within the EPA 33/50 program chemicals, LASC has set an additional goal of eliminating all 1,1,1 trichloroethane (TCA) from LASC operations by April 1994. TCA is an ozone

depleting chemical and is covered in the 1990 Clean Air Act Amendments that implement the Montreal Protocol.

Some of the actions required to eliminate TCA include finding replacements for the large quantities of TCA used in hand wipe and in fuel tank cleaning. In addition to their uses of "pure" TCA, they are working to identify and replace commercial products that contain TCA. To accomplish this, each task is assigned to a group of people with the needed qualifications.

To reduce plant-wide VOC emissions, a number of initiatives are underway. For example, high-VOC paints are being replaced with low-VOC paints; high efficiency painting equipment is being installed to reduce overspray and VOC emissions; degreasers are being upgraded to reduce evaporative losses; and high-VOC cleaners and solvents are being replaced with aqueous cleaning processes or with low-VOC cleaners.

Similar initiatives are underway in the other areas. From this discussion, it is clear that LASC's has an active program for preventing pollution and reducing wastes in its operations.

5.5.1.2 Lockheed Fort Worth Company

Management of the environmental program at LFWC is built on goal achievement and this management style is carried over into the pollution prevention program. The degree of focus on goal setting and measuring progress at LFWC is unique among the companies visited. All of the companies track hazardous waste generation, toxic release inventory (TRI) releases, and a few other metrics, but none measure, track, and manage as intensively as LFWC. This feature stands out from among all the other attributes of LFWC's program.

The LFWC Environmental Resources Management (ERM) staff tracks sixteen metrics monthly, quarterly, and annually. The metrics are shown in Table 5.9. Using the

metrics, LFWC has been able to show substantial progress in its pollution prevention efforts. As of the end of 1992, LFWC achieved the following progress:[95]

100%	Reduction in PCB devices since 1984
95%	Reduction in ozone depleting compound use since 1987
80%	Reduction in effluent heavy metal discharges since 1987
80%	Reduction in TRI chemical off-site transfers since 1987
75%	Reduction in hazardous waste since 1984
66%	Removal/replacement of underground tanks since 1984
64%	Reduction in reported air emissions since 1987
47%	Recycling of non-hazardous industrial solid waste in 1992
11%	Reduction in non-hazardous industrial solid waste since 1991

Other important thrusts to the LFWC effort include implementing hazardous materials management procedures, working with the research and engineering staffs to develop new processes and materials, and involving the employees through training and awareness initiatives.

The Hazardous Materials Procurement, Processing, Disposal & Services section is a part of the materials organization and provides comprehensive management of all hazardous materials and hazardous wastes at the plant. All hazardous materials are purchased, received, stored, issued, collected, recycled, salvaged, or disposed by members of the materials organization. Among the companies visited, LFWC has the best defined hazardous materials and hazardous waste management procedures.

The materials organization operates a permitted hazardous waste storage facility on site. Although this would allow hazardous waste to be stored on-site indefinitely, LFWC's goal is to ship all hazardous wastes to a treatment facility within 60 days. Each drum is tracked by waste type and the number of days in storage. Process control charts are used to track the program's status and are updated daily.

[95]Mckee and Evanoff, 181.

The materials organization also has detailed procedures for tracking and issuing hazardous materials to the work areas. Once issued to the work area, hazardous materials become line management's responsibility in the production organization.

Hazardous materials storage and use in the work areas are monitored by the Production Environmental, Health & Safety section. This two person operation is responsible for conducting self-audits of each work area, hazardous material storage area, and hazardous waste accumulation point quarterly. Results are provided directly to the area's supervisor and to the Vice President for Production. The self-audit results are summarized, tracked, plotted, and displayed on process control charts and are briefed to management on a regular basis. This was the only self-audit program observed at the four companies that is conducted by a production organization.[96]

LFWC also has the most comprehensive wastewater and stormwater compliance programs of the four companies studied. In addition, LFWC's pollution prevention program is the only program among the four that addresses water issues. Over the past ten years, wastewater discharges have been reduced from 1,000,000 gallons per day to 300,000 gallons per day, a 70 percent reduction.

The plant has five permitted wastewater outfalls and a member of the ERM staff visits each wastewater and stormwater outfall each business day. The route covers approximately eight miles along the perimeter of the facility and allows the ERM staff to monitor activities around the plant in addition to conducting sampling and obtaining flow, temperature and pH measurements. This level of attention to housekeeping issues is a necessary, but often overlooked portion of a good pollution prevention program that was not seen at the other sites visited.[97]

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[96]LFWC, as well as the other companies, all have environmental audit programs conducted at the company or corporate level.

[97]On the day the author accompanied the plant representative on the route, we observed a construction contractor cleaning tools in one of the plant's outfalls and identified two drums of hazardous waste not placed in the proper storage location. Both problems were immediately corrected.

As a result of these efforts, LFWC has the most comprehensive air and water programs of the facilities visited and overall, the most advanced facility-based pollution prevention program among the facilities visited.

5.5.1.3 McDonnell Douglas Aerospace - East

Pollution Prevention efforts at MDA-E include strategic planning, developing new materials and processes, improving management systems and processes, and implementing source reduction initiatives. The greatest strength of MDA-E's pollution prevention program is strategic planning. This process is described earlier in Chapter 5, in Section 5.3.2. In addition to the compliance paradigm, MDA-E also has implemented the waste-reduction paradigm.

For 1992, objectives covered a full range of both management and programmatic occupational safety, health, and environmental issues. In the management area, objectives address training, project reviews, communications, customers, and other areas. The environmental programmatic goals cover air emissions, waste minimization, hazardous materials, groundwater protection, and the EPA's 33/50 Program. The programmatic objectives include metrics for measuring progress. For example, one objective includes separate goals for a 90 percent reduction in Toxic Release Inventory air emissions by the end of 2000, a 90 percent reduction in hazardous waste generation by the end of 2000, and meeting the EPA's 50 percent voluntary reduction in the releases of seventeen target chemicals by the end of 1995. Management objectives cover topics like developing and improving hazardous materials control, handling, storage, and use procedures; improving communications with top management on environmental issues; and enhancing line management accountability for environmental issues.

The Environmental and Hazardous Materials Services (EHMS) staff has the responsibility for developing the strategies and actions for meeting the environmental objectives. The staff is assisted by the Environmental Compliance Committee. The

committee is tasked with planning, coordinating, and oversight functions and has representatives from all key MDA-E functions. Working groups are organized as needed to address specific issues. For example, in support of the hazardous waste reduction goal, a working group is assigned for each major MDA-E hazardous waste stream.

Another working group is addressing hazardous materials management. MDA-E uses over 20,000 different materials in its operations and averages over 100 hazardous material purchase requisitions per day for production materials. Each requisition is now being reviewed by a buyer trained to recognize potential problems and to implement MDA-E control procedures. Purchases of non-production materials are not currently reviewed on an individual basis.

Procedures for reviewing all new hazardous materials, equipment, and processes before they are purchased or brought on site for the first time were established in March 1993. The new procedures allow each request to be reviewed by occupational safety, health, and environmental personnel prior to purchasing action. Upon approval, requesters are provided guidance on meeting OSHE requirements that includes information on appropriate engineering controls, pollution controls, disposal, training requirements, worker safety, and related issues. In the first six months since the new procedures were introduced, approximately 200 requests for new chemicals have been reviewed.

Another key element in the strategy for improving hazardous materials management is implementing a Hazardous Materials Tracking System (HMTS). The HMTS will be an on-line data system that ties together data from many existing sources. The HMTS will also support hazardous materials tracking using a bar-coding system. This part of the system is near to pilot testing. Other hazardous material management improvements involve management procedures such as control for hazardous materials hand carried onto MDC property, development of a hazardous material life cycle checklist, and improved shipping and inspection procedures.

5.5.1.4 Pratt & Whitney

The P&W pollution prevention program at GESP has two thrusts: a program-based Hazardous Material Program (HMP) and a facility-based pollution prevention program. For the F119 engine, the HMP is composed of three major tasks: hazardous material reduction, hazardous material tracking, and subcontractor management.[98]

Hazardous material reduction portion of the HMP involves the, "elimination/ substitution/ minimization/ mitigation of all applicable hazardous materials by providing input, guidance and control into the design and development process up front."[99] This is accomplished using several management processes and procedures. Specific steps include the use of integrated product teams (IPTs), the P&W Charter Parts Council, and the design review process.

Each F119 integrated product team (IPT) is responsible for the hazardous material content of its portion of the design. To aid the IPTs in implementing this task, the HMP objectives, guidelines, and training for material selection were presented to the IPT members. Within each IPT, the materials engineering representative serves as a technical expert and as an interface between the IPT and the HMP manager.

The P&W Charter Parts Council provides each team with a set of design norms. These norms provide guidelines for the preferred design, configuration, material selection, and manufacturing process for a specific type of part. The IPTs are expected to follow the design norms, but deviations are allowed if an IPT has good reasons for not following a norm. The Charter Parts Council is a P&W company-wide function and its norms apply to commercial as well as military engines. A guidance document on environmental design considerations was provided to the Charter Parts Council in June 1992. The guidance

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[98]United Technologies, Pratt & Whitney, F119-PW-100 Engineering and Manufacturing Development Program, "Hazardous Materials Program Plan," prepared in response to Contract F33657-91-0007, CDRL A001, Data Item Description OT-90-34207, (Wright-Patterson AFB, OH: Aeronautical Systems Division, 6 March 1992), 2.

[99]Ibid., 13.

provides a consistent set of environmental considerations to be addressed by the Charter Parts Council working group for each type of part.

The final element in P&W's hazardous materials reduction strategy involves using the design review process to assess and obtain control of the amount and type of hazardous materials contained in a design; used in production; or used in repair, maintenance, or support of an engine component. Implementation of the revised review process was accomplished by modifying two internal engineering procedures: the Engineering Task Request (ETR) and Standard Procedure N-8, Hazardous Waste Minimization. The Engineering Task Request is used to authorize and track all design tasks. One of requirements necessary for completing an ETR is "sign-off" on the final design by the IPT and various support functions. Among the IPT's responsibilities are hazardous materials and hazardous waste minimization. ETR procedures assign responsibility for certifying that ,"all possible efforts have been made for elimination, substitution, mitigation, and minimization of hazardous materials and hazardous waste,"[100] to the IPT's Design Metallurgy representative. Design Metallurgy is a part of the Materials Engineering organization. Special Procedure N-8 describes Design Metallurgy's hazardous material minimization responsibilities in detail. Together, these procedures firmly task each IPT with hazardous materials minimization, and specifically task Design Metallurgy with certifying that company hazardous material and hazardous waste minimization policies have been implemented.

The second element of P&W's HMP is hazardous material tracking. Tracking is accomplished using a hazardous material data base (HMDB). The HMDB incorporates information from the Engine Product and Configuration Support (EPACS) data base and the Logistic Support Analysis Record (LASR). The EPACS includes information on all engine end-items and the LASR covers all repair, maintenance, and support process

[100]Ibid., 14.

materials. Together, the combined information covers all applicable hazardous materials. Production materials are tracked separately. Technical information on each hazardous material is taken from its material safety data sheet (MSDS).

Subcontractor management is the third element of the HMP. This task involves incorporating the key elements of the HMP into P&W's subcontracts. Specifically, subcontractors are tasked to identify and document all hazardous materials present in an engine component end item or needed in the repair, maintenance, or support of the item. For the F119 program, this is being accomplished using a hazardous material management clause in the Purchasing and Procurement Specification.

The GESP facility-based pollution prevention program involves tracking process hazardous waste generated, toxic air emissions, and the three largest volume waste streams. The first two of these quantities are also used to track progress toward the UTC and P&W reduction goals. In addition, GESP tracks the use of all volatile halogenated chemicals and reports its TRI data to the corporation to track 33/50 Program goals.

The information is stored in a data base maintained by the environmental staff. The data is regularly sorted by department and each senior manager working for the GESP Vice-President receives a report listing the department's waste generation and progress toward meeting GESP reduction targets.

GESP also tracks non-hazardous solid waste disposal and recycling activity and reports the data monthly to Palm Beach County. Recycling includes paper, cardboard, aluminum, wood, tires, batteries, and concrete. Additionally, GESP sells other scrap metals for recycling. For example, in 1992, GESP reported recycling 79,000 pounds of chromium containing alloys and 170,000 pounds of nickel alloys.

5.5.2 Integrating Facility-based Pollution Prevention Efforts with Acquisition Programs

The impacts and contributions of the companies facility-based pollution prevention efforts on their acquisition programs are easily recognized. The most easily identified

contribution involves the availability of internal company experts on technologies, materials, processes, waste streams, environmental regulations, etc. This core of functional experts was critical at each company in addressing issues raised by the program staff and in some cases seeking out the program staff to ensure they were considering specific pollution prevention measures a functional expert was championing. Other key contributions include developing and maintaining top management support for pollution prevention and the development of company pollution prevention objectives, strategies, policies, and goals. In every case these core contributions and activities formed the foundation for the program-specific pollution prevention activities.

Recognizing the importance of the relationship between core pollution prevention activities and successful acquisition program pollution prevention the industry, led by MDA-E, worked with the Aerospace Industries Association to develop National Aerospace Standard (NAS) NAS411, "Hazardous Materials Management Program (HMMP)."

NAS411's purpose is to set a common standard for defining how a company will influence the product design process to eliminate, reduce, or minimize hazardous materials in acquisition programs while also minimizing system cost and risk to the system's performance. The intent is for the contractor to be able to apply a similar approach company-wide, and not have to set up a different approach for each acquisition program.

NAS411 addresses company-wide efforts in three sections of the document: consistency, applications, and proposal requirements.

> 1.5 Consistency. Tasks described herein are to be consistently applied across all contractor programs, if appropriate, to allow plant-wide uniformity in practices and processes. . .
>
> 3.2 HMMP Applications. The contractor may apply the HMMP on a plant-wide, a contract specific basis, or a combination of plant-wide and contract specific. . .
>
> 4.1 HMMP Plan Proposal Requirements. . . . The Preliminary HMMP Plan shall be submitted to the procuring activity as part of the proposal. The Preliminary

HMMP Plan shall describe an overview of the contractor's HMMP. The successful offeror will provide a full HMMP Plan described in Section 6.2.[101]

As a result of these paragraphs, the core pollution prevention staff at MDA-E and at LFWC have already drafted company HMMP plans that will serve as the basis of new contract proposals. In drafting the plans, each company is faced with addressing the consistency issue.

In moving toward a system of program specific plans that are tightly linked to the work of the core environmental activities, MDA-E believes that program HMMP plans should address the life-cycle of the system, covers program specific issues, identify cost effective solutions, and task implementation of the solutions for the program.

The consistency across programs is to be achieved by linking each program plan to the MDA-E strategic plan. Unlike the program HMMP plans, the MDA-E strategic plan has a MDC business focus, is prepared by the MDA-E core staff, addresses common materials and process issues, identifies MDA-E compliance requirements and projects for addressing the requirements in on-going production operations, and addresses research and development requirements for new technologies.

For 1994, the MDA-E strategic plan includes projects for eliminating the use of ozone depleting chemicals in production processes, switching to low volatile organic compound (VOC) content coatings, reducing emissions from vapor degreasing, and implementing waterborne chemical processing maskants. Projects identified for future years include implementing new technologies for powder coatings, electropriming, adhesive bonding primers, non-chromated conversion coatings, and paint stripping technologies. Additional applications for aqueous degreasing are also planned.

Figure 5.20 shows how the information in the strategic plan will be used in developing program specific HMMP's.

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[101] Aerospace Industries Association, National Aerospace Standard NAS411, "Hazardous Materials Management Program," (Washington D.C.: Aerospace Industries Association, 1993) 1-3.

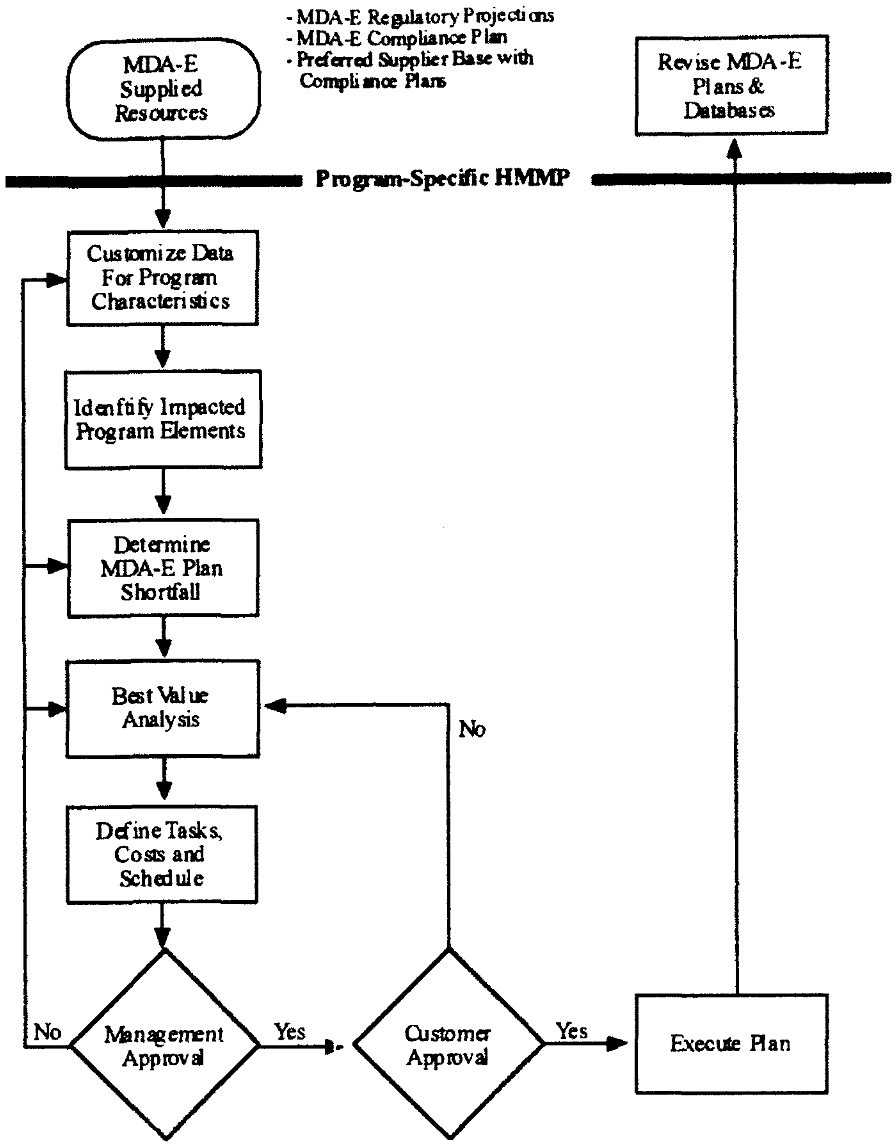

Figure 5.20. Logic Diagram for Developing Program Specific Hazardous Materials Management Plans[102]

A good example of the interaction between program and core responsibilities is MDA-E's ODC elimination efforts. Each MDA-E program manager has had to respond to one or more program specific Government requests for information on impacts and costs associated with implementation of service, DoD, and Congressional ODC policies.

[102]Paul Stifel, "Project Implementation," discussion charts provided during interview by author. McDonnell Douglas Corporation, St. Louis, Missouri, 10 November 1993.

Since the programs share the same production facilities, close coordination between core and program staff is essential to implementing ODC policies in a cost effective manner. If this coordination does not occur, much duplication of effort will occur and much time will be wasted covering the same issues in each program.

To prevent this from happening, EA developed a process flow chart identifying the tasks required for implementing ODC policy caused changes and assigned each task to the program or core staff. For example, reviewing technical publications to identify where ODC use is required in a system is a program task while identifying replacement chemicals is an EA task. Once the tasks were assigned, solutions were identified and funding issues were assessed.

Since many manufacturing processes are shared among programs, EA recommends common solutions to like problems. This is in the interests of both MDA-E and the Government. These potential changes are identified in the EA strategic plan. Funding turned out to be a problem, however. None of the individual Government program managers wanted to pay for changes that benefited all the programs. To move the process forward, MDA-E decided to fund all non-unique (to one system) manufacturing process changes from corporate resources. The costs associated with these changes will then be borne by each program as part of MDA-E's general overhead rate that is applied to all programs. Program unique processes and problems, must be funded by the program. Changes to the technical manuals for a system, for example, must be paid for through a change to the program contract. Redesign and requalification of system hardware are also program specific funding issues.

5.5.3 Corporate Environmental History

In reviewing the pollution prevention programs at each company, the corporate and company environmental compliance history appear to be as significant as any other factor in explaining and understanding each company's current program. In particular, the

number of regulatory actions seems to play a key role in shaping the program's focus and in determining the degree of senior management commitment to pollution prevention.

The corporation that has had the most difficulty with environmental regulators is clearly United Technologies (UTC) and it is no coincidence that UTC has the strongest corporate-level environmental program of the companies studied. In 1991, UTC reported eight violations of Federal and state environmental regulations that resulted in fines. The total paid was over $3.8 million.[103] In 1992, UTC reported five violations resulting in fines of $230,000. Violations that did not result in fines were not reported.

On 24 August 1993, The New York Times and The Wall Street Journal reported that United Technologies settled a series of additional environmental violations for $5.3 million. Quoting information from the U.S. Environmental Protection Agency and the Department of Justice, the article states that, "$3.7 million of the fine was levied under the federal Resource, Conservation and Recovery Act and is the largest civil penalty ever imposed under the law."[104] The remaining $1.6 million of the fine was imposed for violations of the federal and state Clean Water Acts.

The settlement stemmed from a Federal lawsuit filed in September 1990 for violations[105] that included dumping of acid that resulted in a fish kill in the Quinnipiac River; discharging waste water that was not adequately treated into a publicly owned treatment plant; improper handling of hazardous waste; storing hazardous waste without a permit; inadequate record-keeping; and inadequate training.

The New York Times reported on a news conference where,

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[103]United Technologies Corporation, "Environmental, Health, and Safety Progress Report," 8.

[104]Amal Kumar Naj, "United Technologies Fined $5.3 Million for Series of Environmental Violations," Wall Street Journal, 24 August 1993, B6.

[105]The violations occurred at seven Pratt & Whitney plants and at several other United Technologies facilities in Connecticut.

Paul G. Keough, the acting regional administrator for the Environmental Protection Agency, said United Technologies had 'perhaps the worst environmental record of any company' in New England. That record led to a separate $3 million criminal penalty in 1991, then the largest criminal fine in United States history for violating hazardous waste laws.[106]

United Technologies officials stressed that the company had changed its ways.

In agreeing to pay the fines, United Technologies Chairman Robert F. Daniell said, "The attitudes and practices that led to these violations were unacceptable, and we have moved aggressively to change them." . . .

As part of the settlement with the government, the company also agreed to undergo extensive audits of its environmental practices until the end of the decade. . .

Mr. Daniell acknowledged in a letter to employees following the government action that employee training for environmental awareness and compliance at the company hasn't been adequate. Urging more employee involvement, he said, "There should be no need for further wake-up calls from the government."[107]

By the time the final settlement was reached, the changes called for in the agreement were already well into implementation, including the establishment of an environmental auditing program with EPA oversight.

Evidence that the regulators had gotten the attention of top management is obvious in Chairman Robert Daniell's comments in Directors & Boards in 1991:

The regional Environmental Protection Agency (EPA) administrator, in announcing environmental violations at several of our Connecticut locations said, "There have been violations in the past. They haven't set in motion a process to make sure there is continual compliance. So, we have to assume that they have not taken their corporate environmental responsibilities very seriously."

Those are not words a board member, or an employee, or a resident of our plant communities wants to hear. And they most certainly were not the words I, as CEO, want to hear. But such comments--and the fines and warnings that accompanied them--spurred us to redouble our environmental efforts.[108]

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[106]New York Times, "United Technologies to Pay Fines of $5.3 million in Pollution Case," 24 August 1993, Section B, 4.

[107]Naj, B6.

[108]Robert F. Daniell, "Remolding the Environmental Function," Directors & Boards, (Summer 1991): 15.

As a result of this top management attention, UTC has a comprehensive set of environmental policies. They also track more environmental metrics at corporate-level than the other corporations studied. In addition, P&W is developing the most comprehensive set of pollution prevention design tools of any of the companies.

Following UTC, Lockheed is a distant second in looking at corporate regulatory problems. In Lockheed's case the problems and fines were generated by the Occupational Safety and Health Administration (OSHA) rather than by environmental regulators.

In October 1988, Time reported that workers at Lockheed's Burbank plant filed a lawsuit complaining that an unknown toxic agent in stealth materials was causing, "a panoply of ailments--rashes, aches and pains, nausea, memory loss."[109] The Burbank plant involved housed the "Skunk Works" and was the production site of the F-117A stealth fighter. At the time, the F-117 program was still a "black" program. A black program is a program whose existence is classified.

In June 1989, OSHA announced a $1.5 million fine. Roughly half of the 440 citations alleged that Lockheed willfully mislabeled or failed to label chemicals and other materials. "OSHA also charged there was a purposeful lack of records about illness and injuries at the plant."[110] By June 1989, more than 200 workers had filed lawsuits or worker compensation claims.

By March 1989, the publicity (from Lockheed's perspective) became increasingly negative. The National Law Journal reported that:

> The miracle fiber and the wonder plastics may have something in common besides technological whizbangery.
>
> A case in the clerk's office of the suburban courthouse here has a familiar ring for those who watched asbestos litigation grow into a national monster. It complains of a boss conniving to run a poisoned work place, but this time with a nasty twist: What is being built on this assembly line is the top-secret Stealth

[109]Time, "In Sickness and in Stealth," 17 October 1988, 33.

[110]National Law Journal, "OSHA Fines Lockheed on Secret Stealth Jet," 10 April 1989, 14.

bomber, and the defendants are wrapping themselves in the red, white, and blue of national security.[111]

The fine, lawsuits, and the resulting negative publicity served as a wake up call to Lockheed on hazardous materials. It was a turning point in both Lockheed's occupational safety and health program and its environmental program. In addition, while the incident took place in California, it helps explains LASC's approach to managing hazardous materials on the F-22--in particular, the formation, structure, and functioning of the Hazardous Materials Review Board as a management tool for integrating management concerns about worker health, safety, and the environment. This integration among the three functions is stronger at LASC than at the other three sites studied. At the other sites, occupational health, safety, and environment are combined in a single organization, but the three groups of professionals still function very independently from each other.

LFWC has experienced the more frequent environmental compliance inspections among the plants visited. The Texas environmental regulatory authorities have kept a close watch on the plant and have used a "carrot and stick" approach with the facility. While the company has not had to pay multi-million dollar fines, they have had to implement multi-million dollar process changes.

Historically, LFWC's most difficult compliance challenges have concerned air emissions. In 1991, the U.S. District Court ordered General Dynamics to bring its Fort Worth maskant and adhesive prime operations into compliance with the Texas State Implementation Plan (SIP). The company elected to eliminate the maskant process and to install an emissions control system for the adhesive prime operations.[112]

The facility has also had difficulty in meeting the Texas Air Control Board (TCAB) rules for volatile organic compound (VOC) emissions associated with surface coating of

[111]Gail Diane Cox, "Stealth's Other Secrets," National Law Journal, 6 March 1989, 1.

[112]Ejaz Baig, Investigator, Region 8, Texas Air Control Board, "State Implementation Plan Investigation at Lockheed Fort Worth Company," (Austin, TX: Texas Air Control Board, 29 July 1993) 5.

miscellaneous metal parts and products. In June 1993, the TCAB approved GD's Alternate Reasonably Available Control Technology (ARACT) proposal. After signature by the Governor of Texas, the ARACT was forwarded to the U.S. EPA as a site-specific revision to the State Implementation Plan (SIP). With approval of the ARACT, its site-specific requirements now apply in lieu of the "normal" TACB rules. In the ARACT, LFWC agreed to implement a variety of process controls to reduce VOC emissions.[113]

Yet another air emissions issue that LFWC faces involves its use of ozone depleting chlorofluorocarbons (CFCs) for cleaning and degreasing. In the late 1980s, LFWC was the largest user of CFC-113 in the United States. Reducing this usage has been a major undertaking over the past several years.

In past years, the old Texas Water Commission also inspected the facility frequently since the plant's discharges flow directly into a lake that is used by the City of Fort Worth to supply part of its drinking water. As mentioned before, this close oversight has helped LFWC develop the most comprehensive wastewater and stormwater compliance programs of the four companies visited.

In looking at LFWC's record across all compliance areas, the company has struggled to stay in compliance. Between November 1991 and October 1993, LFWC's facilities were inspected 26 times by environmental regulatory agencies. As a result of these inspections, LFWC had four notices of violation in 1993, but none resulted in fines.

Finally, MDA-E by comparison has not had the level of regulatory oversight that the other facilities have experienced. As a result, MDA-E's current environmental program is shaped less by external regulatory forces and more by internal management choice.

This has permitted the current environmental assurance (EA) organization to be created, organized, and developed in a non-crisis mode of management. This is the exception among the facilities visited. EA is unusual in another way in that it was created

[113]Ibid.

locally without strong management support from the corporate level. The vision and support for the organization appear to come from the Vice President for Integrated Product Development.

5.5.4 Implementation Summary

The facility-based pollution prevention programs at all four facilities studied are well developed. They have all have been in operation for five to seven years with the exception of MDA-E's program, which has only been active for the past two to three years. This is evident in the relatively small reductions MDA-E has achieved in the release of toxic release inventory (TRI) chemicals.

Integrating facility-based pollution prevention efforts into acquisition programs has been a challenge at all of the companies. The aerospace industry has addressed this issue and developed National Aerospace Standard NAS411 as a response. Two companies, MDA-E and LFWC have begun to develop the organizational and management tools needed to implement NAS411, but only MDA-E is operating in a true multi-program organizational environment. MDA-E has addressed how it would like to approach the integration of core functions and programs on paper, but has does not yet have enough actual experience to determine how well the effort will succeed.

An important factor in understanding the facility-based programs at the companies is the environmental compliance history at the site. This is illustrated by the close match between areas that have been subject to the most intense regulatory enforcement and the corresponding development of that area into a strong point in the company's environmental program. This indicates that the enforcement activities of regulatory agencies have a much bigger impact on the organization than simply correcting immediate compliance difficulties. As in the case of UTC, continuing enforcement pressures will produce major organizational changes and will redirect resources within a company.

5.6 Summary, Conclusions and Recommendations

In answering the research question, how is pollution prevention implementation proceeding, a number of conclusions have been identified in four general areas of pollution prevention implementation in the aerospace industry: 1) pollution prevention paradigms, 2) company pollution prevention programs, and 3) acquisition program management.

5.6.1 Pollution Prevention Paradigms

Three distinct pollution prevention paradigms were observed at the four companies and each paradigm focuses on a different aspect of pollution prevention (wastes, design materials, or compliance regulations), asks different questions, requires different information for analysis, involves different people, and often, produces different results. Understanding these differences is important in trying to why the paradigms may produce different results.

The starting points for analysis are critical because they frame "the problem" to be solved. In the waste-reduction paradigm, there is a goal setting step, but no identification step. This paradigm frequently begins with the assumption that the problems are obvious and the major task is to prioritize the problems and to set goals. In this paradigm, the wastes streams to be considered are assumed to be clearly defined and they can often be easily quantified. Because of this, goals for reduction can be easily and arbitrarily set.

In the 1990 report, Reducing Risk: Setting Priorities and Strategies for Environmental Protection, the EPA Science Advisory Board cited this type of goal setting as one the key problems EPA faces:

> As different environmental problems were identified, usually because the adverse effects--smog in major cities, lack of aquatic life in stream segments, declining numbers of bald eagles--were readily apparent, new laws were passed to address each new problem. However, the tactics and goals of the different laws

were neither consistent nor coordinated, even if the pollutants to be controlled were the same. . .[114]

Another characteristic of the waste-reduction paradigm is that it often results in efforts to reduce wastes by controlling the processes that produce wastes instead of looking further back up stream in the product life cycle--at the product design. In the cases studied, reductions in TRI chemical releases have been achieved without redesign of the product. While exact figures are not available, material and process changes account for almost all of the reductions. This conclusion is strongly supported by the listings of pollution prevention projects and initiatives that the staff at each company maintains.[115]

Focusing on materials and processes also has important implications for the organization. The environmental management organizations at each company are responsible for the EPA 33/50 Program and their hazardous waste minimization program. In addition, the integrating structures that the companies have developed typically do not include product designers. At LFWC, the Hazardous Materials Management Program Office (HMMPO) has a Research and Engineering representation, but the representative is from the materials and processes function. The HMMPO also has a materials and processes representative from the F-22 program. At LASC, the hazardous waste minimization group (to become a pollution prevention committee) also includes materials and processes engineers. At P&W, the materials and processes function is assigned responsibility for pollution prevention in design. At MDA-E, the subcommittees assigned to specific waste streams include representatives from the materials and processes

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[114]U.S. Environmental Protection Agency, Science Advisory Board, Reducing Risk: Setting Priorities and Strategies for Environmental Protection (Washington D.C.: U.S. Environmental Protection Agency, September 1990), 1, SAB-EC-90-021.

[115]The projects are characterized in the individual case studies, but the actual lists provided by the companies have not been approved for publication here. There are published papers that describe the pollution prevention programs at each company that provide partial listings of the projects and initiatives. For example, the papers by Mckee and Evanoff describe projects at LFWC, the paper by Edwards, Giles, and Hirsekorn describes the initiative at LASC, and the paper by Flynn discusses initiatives at P&W. All four papers are listed in the Bibliography.

function, but no product design engineers from the programs (such as the F-15, F-18, AV-8B, etc.). Since product designers are rarely involved in pollution prevention efforts, potential waste reductions that can be achieved through product redesign are not "discovered," evaluated, or implemented.

In the acquisition programs, part of the reason for this lack of design involvement is probably do to the lack of support pollution prevention has had within the government program offices. The companies were tasked to meet reduction goals by their parent corporations, but their customer was not supportive of pollution prevention, and in some cases the customer was hostile toward prevention efforts that involve redesigning a system that "works." This discouraged the companies from examining potential design changes as a means to achieve pollution prevention.

Staffing is another factor that has impacted implementation of the waste-reduction paradigm. With the exception of MDA-E (in the last year), environmental staffing at the companies has been flat. This has forced the staffs to continue in their compliance responsibilities while taking on new pollution prevention responsibilities. Since this work load could not be accomplished within the available staff hours and existing technical expertise, help from other functional areas was sought. The support is being provided using the various integrating techniques the companies have put in place, but the focus of the task is still to reduce waste.

In the design-materials paradigm, the analysis proceeds in a forward direction but "the problem" is not always so clear. By starting with design materials, the environmental impacts associated with using different materials are not obvious. Assessing these impacts from design, to production, to customers, to wastes requires an environmental impact analysis of each alternative. This requires a much greater amount of information and analysis than working backward from a given design and waste stream.

At LASC, where the design-materials paradigm has become the predominant paradigm, this level of analysis is not accomplished. Decisions are made based on a

material's intrinsic properties and risks. Waste volumes, environmental impacts, and treatment and disposal costs are not routinely analyzed. Thus, just as activities at the beginning of the product life cycle are inadequately considered in the in the waste-reduction paradigm, impacts at the end of the life cycle are inadequately considered in LASC's implementation of the design-materials paradigm. The paradigm is also used at P&W, but even less analysis is conducted than at LASC.

Organizationally, implementation was initially seen as predominantly a materials and processes responsibility at both LASC and at P&W. In their implementations, the environmental, health, and safety staffs serve as technical advisors. Engineering designers are not fully integrated into the process at either company, but the process does influence design.

The compliance paradigm initially appears to be similar to the waste-reduction paradigm because the many environmental compliance regulations address wastes but on closer examination the dynamics involved are somewhat different. First, some regulations address technologies, other address administrative requirements, and others address specific chemical uses such as the phase out of ozone depleting chemicals. In addition, compliance usually has a cost associated with it for the company. This represents an opportunity cost for pollution prevention and a potential competitive advantage for the company. Thus, "the problem" in the compliance paradigm is frequently different than the issues raised in the waste-reduction paradigm (although these can be important issues in the waste-reduction paradigm as well).

At MDA-E, the forward looking nature of the process (it tracks potential requirements and draft rules), produces a different set of organizational actors. At MDA-E, the corporate legal staff (and other functional staffs on a case-by-case basis) plays a large role. Not only does the corporate staff help to track and evaluate potential new requirements, they also seek to influence the outcome of the policy processes that are producing the requirements. This lobbying aspect of the process is not shown on

MDA-E's diagram of the process that is shown in Figure 5.6 and it was not observed in the other paradigms.

In addition to the paradigms described here, other paradigms with other starting points for analysis can be envisioned. The three observed paradigms along with three additional potential paradigms are listed below along with their starting points:

	Paradigm	Starting Point
1.	Waste reduction	Waste Streams
2.	Design Materials	Design Materials
3.	Compliance	Compliance Regulations
4.	Subsystem	Parts or Subsystems
5.	Product	Product or System
6.	Life-Cycle Assessment	All inputs and outputs

The relationship among the starting points of the paradigms can be seen in the product life cycle illustration shown in Figure 5.21 where the starting points are represented by the highlighted numerals. The life cycle stages are shown at the top of the figure and the border around the process represents the constraints on the system that result from environmental regulations. Within the border, the relationships among raw materials, parts, subsystems, and the complete system are shown.

The first three paradigms have been described earlier. Paradigm 4, the subsystem paradigm, does not focus on inputs or on outputs, but instead, focuses on a part or a subsystem. The Charter Parts Council at Pratt & Whitney (P&W) may be an example of the subsystem paradigm.[116] The Charter Part Council develops sets of design norms for the important components of jet engines. The norms provide guidelines that cover design, configuration material selection, and manufacturing processes for each type of part.

Other potential examples of the subsystem paradigm can be seen in the design for environment literature. For example, Keoleian, Glantschnig, and McCann recently

[116]The paradigm is not described in detail because only limited first hand information on the activities of the Charter Parts Council was obtained during the site visit.

reported on what they called a life cycle design demonstration project.[117] The AT&T project involved the design of a new business telephone, the 8403 terminal.

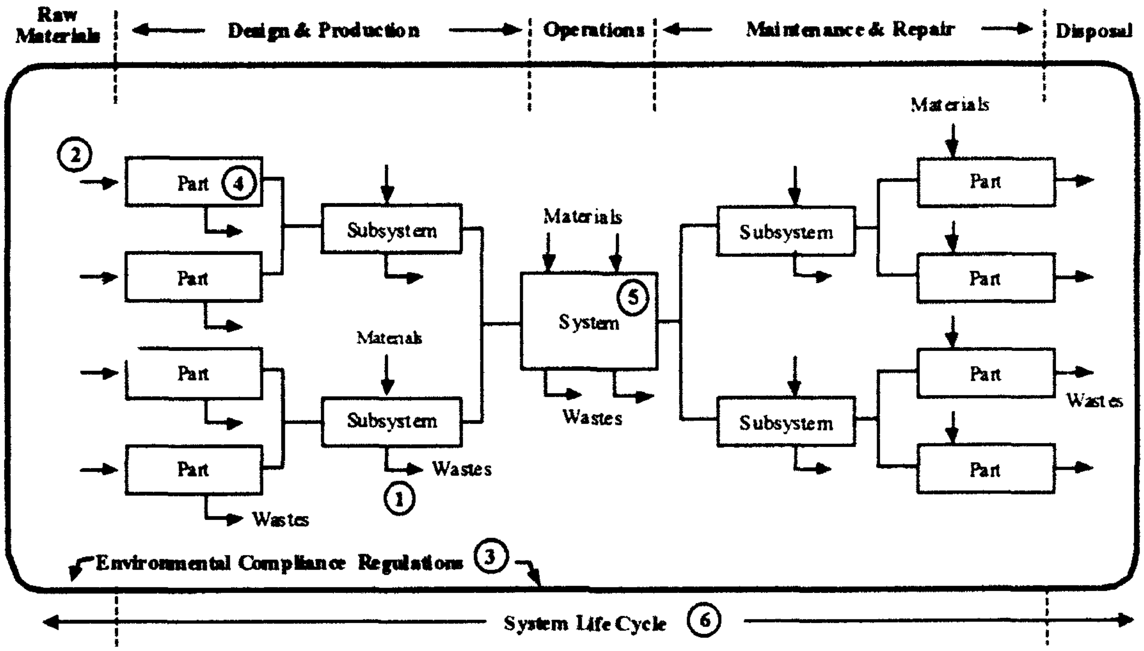

Figure 5.21. Pollution Prevention Paradigms

The design requirements specified that the plastic for the telephone housing should be both recycled and recyclable, toxics be eliminated, and, in order to conserve resources and reduce waste, defective products be minimized. Since the requirements were set without performing a life-cycle analysis to determine if recycling plastic was indeed the best environmental solution, the project does not represent the life-cycle assessment paradigm. In addition, since the basic electrical and mechanical inner workings of the telephone were not considered, the project is not an example of the product paradigm. Instead, the project actually centered on the housing subsystem of the telephone. The final

[117]Gregory A. Keoleian, Werner J. Glantschnig, and William McCann, "Life Cycle Design: AT&T Demonstration Project," in the Conference Record of the International Symposium on Electronic and the Environment, held at San Francisco, CA, 2-4 May 1994, (Piscataway, NJ: Institute of Electrical and Electronic Engineers, 1994), 135A-135H.

design included a number of strategies for reducing plastic molding waste and for reducing contamination of the plastic when it is recycling by allowing the easy separation of non-plastic components from the housings.

Paradigm 5, the product paradigm, looks at an overall product. An example of this approach was reported by Schutzenberger.[118] Using a rating process, Hughes Radar Systems developed a model that measures how "green" a new design is. The system can rate a design as the design process proceeds and can be used at both the system and subsystem levels. At Hughes, designs combine standard specifications for each type of component of a new system much the way repair tasks are developed at P&W (see Section 5.4.2). In the Hughes model, each material and process is assigned a score which is then combined and weighted to form an aggregate score. The system is being applied to a new design where a target score for the product was set as a design goal.

Paradigm 6, the life-cycle assessment paradigm,[119] is a holistic paradigm for analyzing the environmental releases and impacts of a hazardous material, product, process, or activity over the entire life cycle. Life-cycle assessment is clearly the most comprehensive paradigm, but its also has major limitations. The large data requirements and the complexity of analysis make this method time consuming and costly. In addition, life-cycle assessment is new and so far has only been applied to relatively simple consumer products.

A key conclusion from this review of pollution prevention paradigms is that there are at least three paradigms for implementing pollution prevention and the paradigms

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[118]Chris Schutzenberger, "An Electronic, On-Line Database for Quantitative Environmental Assessment of New Designs," in the Conference Record of the International Symposium on Electronic and the Environment, held at San Francisco, CA, 2-4 May 1994. (Piscataway, NJ: Institute of Electrical and Electronic Engineers, 1994), 183-186.

[119]Society of Environmental Toxicology and Chemistry, Workshop Report, A Technical Framework of Life-Cycle Assessments, held at Smugglers Notch, VT, 18 August 1990. James A. Fava, Richard Denison, Bruce Jones, Many Ann Curran et al, eds., (Washington D.C.: Society of Environmental Toxicology and Chemistry, January 1991).

require different information, have different organizational impacts, focus on different parts of the product life cycle, and produce different results.

5.6.2 Pollution Prevention Programs

Pollution prevention programs have their roots in each of the three types of basic corporate objectives: products and markets, financial and profitability, and social and psychological. These basic categories of objectives correspond to the main criteria that will be used in evaluating pollution prevention opportunities: customer demand for green products, economic considerations, and regulatory compliance. When all three types of objectives are present, pollution prevention involves a mix of technical, economic, regulatory, and institutional considerations[120] that must be integrated into the decision making processes of the organization. In practice, the pollution prevention activities at each of the four companies are based on a combination of corporate-level and company-level environmental objectives and policies.

At the corporate level, pollution prevention is addressed within the each corporation's broad environmental policy, and in each case, pollution prevention is framed as a social objective. None of the corporate policies include a product or a financial objective as part of its pollution prevention objectives. In addition, the corporations all participate in EPA's 33/50 Program, and all have hazardous waste reduction objectives and goals. The fact that the 33/50 Program is a central part of each corporation's pollution prevention efforts indicates that a voluntary government effort can have important impacts on the policies and actions of the aerospace industry

At the company level, three of the four companies (LASC, LFWC, and P&W) have detailed environmental policies and procedures, but the implementation details vary greatly in terms of what is to be done, who is to do it, and how it should be done. Since all of the

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[120]Karen Shapiro, Rebecca Little and Allen White, "To Switch or Not to Switch: A Decision Framework for Chemical Substitution," Pollution Prevention Review, (Winter 1993-94): 3-14.

companies participate in the EPA 33/50 program, this provides one method for comparing the programs. Reductions in the release of the toxic release inventory (TRI) chemicals included in the 33/50 Program range from high of 76 percent at LASC and LFWC, to a low of 4 percent at MDA-E, based on 1992 TRI data and using a 1988 baseline.

One important factor in explaining this wide difference in company-level reductions is the corporate history on regulatory compliance issues. The corporations that have a history of compliance violations also have the strongest records in achieving pollution prevention success. All of the corporations except McDonnell Douglas have had continuing compliance problems. In addition to the differences seen in the 33/50 Program and in their compliance histories, the companies are pursuing different solutions to some common implementation problems.

Organizational structure is a challenge because of the difficulty the companies are having integrating pollution prevention across functions and programs. Among the organizational techniques employed are revising existing functional responsibilities, creating a new functional staff, adding new technical specialists to matrix management arrangements, and using committees, teams, and boards; however, none of the techniques has been fully successful in achieving the degree of integration needed. At both LASC and LFWC, the integration structures are able to accomplish specific integration tasks, but are not well suited to integrating among functions and programs on a comprehensive basis. MDA-E and P&W have developed new functional arrangements to try to cope with the need for more comprehensive integration. While both initiatives are still evolving, both look more promising than trying to bridge the functional and program structures solely with committees, teams, and boards.

At MDA-E, a new function, Environmental Assurance, was created and staffed with a multi-disciplinary, multi-functional combination of people. The EA represents an integrated product team that has been brought together as a core functional staff. EA has engineers, managers, logisticians, and scientists with extensive program management

experience, design and testing experience, environmental management experience, research and development experience, production experience, and logistics experience. Because of its makeup, EA is unique among the organizational structures studied and significant because it attempts to overcome functional barriers using a dedicated multi-disciplinary team. All of the other arrangements studied see pollution prevention as either an environmental issue or as a technical engineering problem. Another important factor that makes EA unique is that the strategic planning and program support for pollution prevention are in a separate functional area from the day-to-day regulatory compliance responsibilities. This prevents the compliance activities from consuming most of the staff's time as happens at the other companies.

At P&W, design responsibility for pollution prevention in new products has been assigned to Material Engineering. Responsibility for facility pollution prevention remains in the environmental management function. This split recognizes key differences in implementation methodologies and technical backgrounds that are needed to implement pollution prevention in the different areas. Another important technique that P&W is employing is integrating pollution prevention into the design norms for families of parts used in the company's engines. The design norms are maintained by the Charter Parts Council which has representatives from P&W's different functions, products, and locations. While including pollution prevention and other environmental concerns in the norm development and update process is relatively new, the technique may develop into a fourth paradigm (with the part or subsystem as the starting point of analysis) as well as an innovative organizational structure.

Funding and staffing are key resource constraints that are impacting pollution prevention implementation and both constraints have internal and external components. Internally, pollution prevention programs must compete for a portion of each company's core overhead resources. Pollution prevention initiatives have been relatively successful in competing for resources and this is reflected by the fact that all of the companies have

funded internal research and development efforts as well as numerous pollution prevention projects for reducing releases. Based on the relative success pollution prevention initiatives have enjoyed at each company, the internal budgeting process has not been as big of an implementation problem as have external funding and staffing.

In an industry that has been down sizing for several years, none of the environmental staffs have been reduced, but nor have they grown except at MDA-E. In spite of the down sizing, very little reduction in the environmental compliance work load is realized until production processes are completely eliminated. In some cases, down sizing causes more problems. At GESP, the wastewater treatment facilities were designed for much larger flow rates than currently exist. This causes continuing operational difficulties at the plant in meeting discharge standards. Since the work load associated with existing regulatory compliance requirements has not significantly changed and new requirements are always being added, staffing for undertaking new facility-based and program-based pollution prevention efforts is very limited. Because of this staffing shortage, the current level of effort falls well short of what managers at each company acknowledge is needed.

Finally, the government has provided very limited funding for pollution prevention activities in its program contracts, forcing the companies to fund most activities from corporate overhead. This sends mixed messages at best to the companies about the government's intentions. Many in industry believe the government wants pollution prevention but wants industry to pay for implementation.

5.6.3 Acquisition Program Mangement

The conclusions for acquisition program management fall into two general areas: 1) funding, and 2) policy and procedures. For pollution prevention to succeed in acquisition programs, the government must recognize the programmatic costs and fund them. In the programs studied, funding issues were mentioned by the management and staff in every program. For example, at MDA-E funding for changes needed to eliminate

ozone depleting chemicals was a common problem. None of the individual Government program managers wanted to pay for changes that benefited all the programs. To move the process forward, MDA-E decided to fund non-unique (to one system) manufacturing process changes from corporate resources. The costs associated with these changes will then be borne by each program as part of MDA-E's general overhead rate that is applied to all programs. Program unique processes and problems, must be funded by the program.

On P&W's F119 program, a lack of government funding to qualify "greener" materials and processes for use in standard procedures is causing new technical data to be written that call for the use of chemicals the Air Force is working to eliminate. The standard procedures are used to maintain and repair all P&W engines in all the services; however, none of the individual programs wants to pay for qualifying new materials and processes that benefit all engines.

In addition to the funding issues, there are also three issues that impact DoD policies and procedures. The first issue involves collecting, storing, and distributing the technical information needed to implement pollution prevention in the hundreds of DoD acquisition programs. Since the informational needs for individual programs overlap, the efficiency of gathering and distributing the information on design techniques, hazardous materials, manufacturing processes, and other common pollution prevention information can be enhanced by adopting procedures that improve information sharing among programs.

Similarly, the cost of incorporating new technical information into DoD's existing technical publications is a problem. In preparing proposals for the Government on ODC elimination, MDA-E discovered that the cost to change the program technical documentation far exceeds the costs of finding and implementing the changes. A key finding from this effort is that technical documentation systems must be redesigned to reduce the costs associated with making changes.

The second set of issues in the policy and procedures area were identified in studying the how the pollution prevention paradigms are being implemented. In each

program observed, one or more government inputs were absent. Missing inputs include environmental requirements, criteria, and goals. In addition, the acquisition process does not require that environmental compliance requirements at operating locations be explicitly recognized as a design constraint nor does the process recognize the dynamic nature of environmental regulations.

To improve implementation of pollution prevention in system acquisition programs, DoD policies and procedures must ensure new systems meet state as well as federal environmental regulations, address new environmental regulations, and provide missing government inputs. In addition, different pollution prevention paradigms are associated with different pollution prevention objectives, it is probably not desirable to try to construct detailed step-by-step guidance for conducting pollution prevention in acquisition programs. Instead, DoD policy should ensure that pollution prevention objectives are set and that analysis appropriate to the objectives is carried out.

Finally, the case studies illustrate that successful implementation of pollution prevention in acquisition programs is related to having a successful facility-based pollution prevention program. The impacts and contributions of the companies' facility-based pollution prevention efforts on their acquisition programs are easily recognized. The most easily identified contribution involves the availability of internal company experts on technologies, materials, processes, waste streams, environmental regulations, etc. This core of functional experts was critical at each company in addressing issues raised by the program staff and in some cases seeking out the program staff to ensure they were considering specific pollution prevention measures a functional expert was championing. Other key contributions include developing and maintaining top management support for pollution prevention and the development of company pollution prevention objectives, strategies, policies, and goals. In every case these core contributions and activities formed the foundation for the program-specific pollution prevention activities.

CHAPTER VI

POLLUTION PREVENTION IN SYSTEMS ACQUISITION

6.1 Pollution Prevention Implementation Framework

The pollution prevention framework that was developed in Chapter 3 seeks to form an integrated approach for pollution prevention in systems acquisition. The framework, shown in Figure 3.9, includes concepts from three areas: 1) pollution prevention--the principles of life cycle design, 2) system engineering and design--the requirements for a new system design control technique, and 3) environmental impact analysis--the standards of analysis required for improving organizational intelligence.

In this chapter, information from the case studies together with information collected at DoD, from individual program offices, and from Air Combat Command at Langley AFB, Virginia is evaluated using the framework's criteria to answer the research question: To what extent--and how--are the pollution prevention framework criteria being met? Then, a concept for implementing pollution prevention into the systems acquisition process is developed.

6.2 Pollution Prevention Principles

There are four pollution-prevention principles in the framework and each is addressed in this section:

1. Recognition of all activities involved in product and process design from extraction of raw materials to the ultimate fate of residuals.
2. Inclusion of environmental requirements at the earliest stages of product development.
3. Use of cross-disciplinary development teams.
4. Recognizing environmental impacts as measures of quality.

6.2.1 Life-Cycle Design

The life-cycle principle has two major implications for system development. First, the boundaries for any systems analysis should include the life cycle of the system's materials and the wastes produced. Second, and logically following from this, all prevention alternatives or options over the life cycle should be considered before selecting which combination of options will be employed.

Prior to conducting the site visits it was apparent to this author that basing material selection decisions on an analysis of life cycle impacts would be difficult to implement. The four companies studied confirmed this judgment. None of the companies currently has a design methodology that considers life cycle impacts in other than the most general terms nor do they believe that they will have a satisfactory methodology within the next five years.

At MDA-E, Environmental Assurance (EA) is sponsoring an internally-funded research and development (IRAD) project to develop a *hazardous materials cost model.*[1] Begun in 1992, the objective of the effort is to develop an analysis tool that can be used to perform trade studies on hazardous materials and processes. The immediate goal is to support the trade studies needed on the F/A-18E/F and T-45TS programs.

Determining the life-cycle cost of a hazardous material or process is different than performing a trade study. The life-cycle cost includes research and development cost, production and construction costs, operation and support cost, and retirement and disposal cost. In performing a trade study, the objective is to develop enough information to make a decision, while balancing the cost of obtaining the information with the costs

[1]The model, like a similar model the Air Force is developing, is process based rather than material based. This means that modeling process starts by identifying the "hazardous" manufacturing steps or processes such as chemical milling, plating, and painting. The modeling process then proceeds by attempting to evaluate process and material alternatives within the broad process category. For example, for painting, the model might consider different methods for applying the coating and different painting materials.

and uncertainties inherent in the decision. Because of this trade-off between cost, information, and risk, environmental trade studies, like other types of trade studies, often involve estimating something less than true life-cycle cost. For example, the sunk cost associated with research and development, construction, and past operations may not be relevant to decisions on reducing the volume of a waste stream. In this case, only the future cost associated with each alternative is important to the decision.

When asked about the model's ability to calculate life-cycle costs, those involved believed that they are no closer now than they were two years ago when the project started. This does not mean that meaningful information for decision making cannot be generated with the model. It does mean that the challenges in modeling and data collection to support general design decision making are large and will probably not be satisfactorily solved quickly. Because of this, the model is being developed to support a limited set of processes of known interest on the F/A-18E/F and the T-45TS.

At P&W, two major initiatives for incorporating life cycle impacts during system design are in place and third that will include environmental considerations in the company's automated design system is underway.

First, the P&W Charter Parts Council (CPC) provides a "living" knowledge base on designing and manufacturing jet engine parts. CPC part norms currently address configuration, materials, and production processes. P&W is adding information on environmental impacts and risks to the company's detailed design and manufacturing guidelines. The design guidelines, drawn from the experiences of each of the relevant design disciplines (structures, reliability, manufacturability, maintainability, etc.) are then used by design teams in developing detailed designs.[2] Thus, the design guidelines provide

[2]Joseph Fiksel, "Design for Environment: An Integrated System Approach," in the Proceeding of the International Symposium on Electronics and the Environment held at Arlington, Virginia, 10-12 May 1993, (Piscataway, NJ: Institute of Electrical and Electronic Engineers, 1993) 128.

an important tool for capturing historical information on life cycle impacts that can easily be used in a concurrent engineering design approach.

The second initiative is P&W's "Environmental Considerations Manual." The manual provides designers with a concise set of guidelines on the materials and processes that should be eliminated or minimized and is available to all that need it including CPC members and program design teams.

"Vision 2000" is P&W's computer aided design (CAD) initiative for the future and will provide a designer at a computer work station immediate access to all the information needed for design including design manuals, criteria, specifications, CPC norms, Rule Base, a "How-to-Design Book," and environmental considerations for eleven major part families.[3] P&W is developing the design methodologies that will be used on the system as part of a multi-industry consortium. The consortium has eleven other members and is organized under the National Center for Manufacturing Sciences (NCMS).

At LASC, efforts to address life cycle environmental issues have been incorporated into the design-materials paradigm discussed in Chapter 5. These efforts include using qualitative risk assessment and management techniques for the selection of hazardous materials and the preparation of design guidelines for processes that are known to use large quantities of hazardous materials or to generate hazardous wastes during operations and maintenance.

These examples illustrate that substantial work is needed to develop better design guidelines, cost models, and design methodologies that will enable designers to achieve the objectives of the life-cycle design principle.

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[3]John E. Flynn, "The Role of DFE in the Pollution Prevention Strategy of an Aerospace Producer," draft paper prepared for the International Symposium on Electronics and the Environment to be held in San Francisco, CA, 2-4 May 1994, (Hartford, CT: Pratt & Whitney, 1994), 5.

6.2.2 Environmental Requirements

Identifying environmental requirements in the development process requires: 1) early environmental analysis, 2) the translation of the results into specific design requirements that address important environmental issues, and 3) acquisition mechanisms for accommodating the evolving nature of environmental compliance requirements.

The issues associated with early environmental analysis will be covered later in this chapter in discussing the environmental impact analysis process. The problems associated with the evolving nature of environmental compliance requirements were presented in Chapter 5 as part of the discussion on the strategic-planning paradigm where it was illustrated that it may be possible and desirable to avoid changing most program requirements, but it is not possible to successfully develop and field a new weapon system without adapting to changes in environmental compliance requirements.

A summary of program pollution prevention design requirements is presented in Table 6.1. The table is organized in chronological order based on the date the system was, or will, enter operational service. The table shows that there is a trend toward more specific pollution prevention requirements in the most recent contract documents. Details on the programs shown in the table are included in the case studies. The table shows that with the exception of the F100 engine, environmental requirements are relatively new.

Among the airframe contracts, the F-22 contract was the first to include environmental requirements.[4] The requirements include identifying hazardous materials, contractor selected analysis, and data submittal. The contract language amounts to saying that the government is concerned about hazardous materials and expects the contractor to do something to respond to the government's concerns. Lockheed's response to the government's concerns resulted in the development and implementation of the identification-evaluation paradigm.

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[4]While the F/A-18 E/F is scheduled to enter operational use first, the F-22's contract requirements for hazardous materials were part of a 1991 contract that pre-dates the F/A-18E/F contract.

Program	Contract Requirements	Year
C-130	- None	1956
F-15	- None	1974
F100 Engine	- Requirements for air emissions - Measurement of noise data - Reduce hazardous materials used during repair (newest version only)	1974
F-16	- None	1978
AV-8B	- None	1982
F/A-18C/D	- None	1983
T-45TS	- Reduce & Eliminate -- Ozone Depleters -- High VOC Topcoats -- Methylene Chloride -- Cadmium Plating - Evaluate Alternatives -- Detergents -- UNICOAT TT-P-2756 -- Plastic Media Blast -- Carbon Dioxide Blast -- Benzyl Alcohol -- IVD Aluminum - Identify operations and maintenance tasks using hazardous materials. - Identify hazardous material and waste quantities.	1992
F/A-18E/F	- Identify unique hazardous materials used in manufacturing and support of the F/A-18E/F. Perform and submit: -- Logistics Support Analysis Tasks -- Cost Trade Studies -- Environmental Analysis Report	1998
F-22	- Identify and control hazardous materials -- Develop and implement a Hazardous Material Program Plan -- Submit data on hazardous materials to the Government -- Record decisions on hazardous material uses	2002
F119 Engine	- Identify and control hazardous materials -- Develop and implement a Hazardous Material Program Plan -- Submit data on hazardous materials to the Government -- Record decisions on hazardous material uses - Requirements for air emissions - Measurement of noise data	2002
A/F-X (canceled)	- Justify uses of hazardous materials - Identify hazardous material substitutes - Flow-down pollution prevention to subcontractors and vendors	2010

Table 6.1. Summary of Pollution Prevention Contract Requirements

Compare the F-22's general requirements to the specific requirements for the T-45TS. The T-45TS contract includes identification and reporting requirements for hazardous materials similar to those on the F-22, but it also includes pollution prevention requirements addressing specific materials and processes.

On the F/A-18E/F program, the environmental requirements are contained in the logistics support analysis (LSA) provisions of the contract. The contractual environmental tasks are illustrated in Figure 6.1.[5] The environmental portion of the LSA process occurs in two LSA tasks: Task 204, Technology Opportunities; and Task 401, Task Analysis.[6]

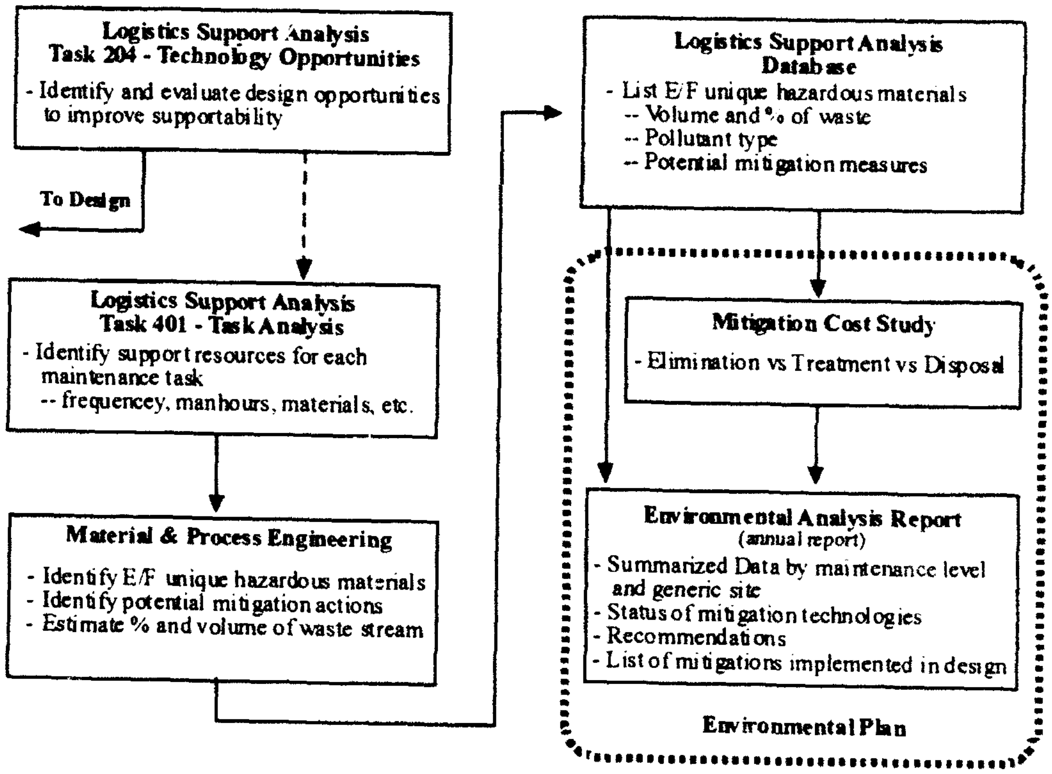

Figure 6.1. F/A-18E/F Environmental Analysis

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[5]McDonnell Aircraft Company, "F/A-18E/F Integrated Logistic Support Environmental Analysis Plan," (St. Louis, MO: McDonnell Aircraft Company, 23 September 1991), 2-6.

[6]The portion of the LSA process shown represents a small part of the overall LSA effort. For the F/A-18E/F, the contractual LSA requirements are a tailored subset of the complete LSA process described in MIL-STD-1388.

Under Task 204, MDA-E is required to assess opportunities to improve system supportability by identifying technological advances and other design improvements which have the potential for reducing logistic support requirements, costs, or environmental impacts; improving safety; or enhancing system readiness. The intent of this task is to provide logistics inputs early in the design process. For the F/A-18E/F, environmental inputs from this task are based on MDA-E's compliance requirements as identified in their Environmental Assurance (EA) strategic plan.

Task 401, which contains most the contract's environmental requirements, requires MDA-E to assess opportunities to improve supportability and to identify and evaluate E/F aircraft unique hazardous materials that will be used in manufacturing or support. This includes carrying out task analyses of all maintenance and repair activities. Task analysis has limited impact on the design process; however, since the bulk of the analysis occurs following critical design review. This makes it impossible for MDA-E to use information from Task 401 to "design out" hazardous materials during the concurrent engineering process. Since source reduction items are not presented in the design process in a timely way, potential changes require reconsideration and redesign resulting in higher costs.

Of the contracts reviewed, the F119 engine contract includes the broadest set environmental requirements (note that many of the T-45TS requirements are for studies). In addition to the set of hazardous materials requirements that are similar to the F-22's requirements, the F119 prime item development specification (PIDS) contains a host of operational, logistics, and safety performance criteria that directly impact the environment. The requirements include quantitative limits for emissions of oxides of nitrogen and require testing to determine emissions of nitrogen oxides, carbon monoxide, and hydrocarbons; limits for smoke emissions; limits on leakage rates from the fuel system, oil system, and hydraulic system; and they prohibit the use of specific materials in certain applications. Compliance with these requirements is verified during the engine testing program. For example, during engine tests all external leakages are collected, measured,

and reported so that five separate leakage limits can be verified. For the fuel system, overboard drain leakage must be less than five cubic centimeters per minute with the engine running and less than ten drops per hour at cutoff. In addition, static and dynamic leakage from any fuel system source other than the overboard drain, must be less than one drop per hour. Similar limits apply to the oil and hydraulic systems.

These examples illustrate that the environmental requirements in existing contracts are uneven in scope and depth. In the airframe contracts, pollution prevention requirements are still relatively new and have not been fully integrated into system specifications. On the jet engine contracts the experience is different. The environmental issues associated with jet engines, especially air emissions and noise, have been major environmental issues for a long time and the "requirements development system" addresses them routinely. This difference suggests that the requirements development system is capable of integrating pollution prevention requirements.

Reviewing DoDI 5000.2 confirms that the current *requirements development* policy is broad enough to address pollution prevention issues. The policy on evolutionary requirements development and on critical system characteristics does not specifically include nor exclude environmental issues.[7] The policy is not prescriptive--it is a statement of philosophy on keeping the initial set of performance objectives and requirements to a minimum and then developing progressively more detailed objectives and requirements at successive milestones as a consequence of cost-schedule-performance trade-offs made during development.

While specific mention of environmental issues would be helpful, it is not a necessity. Given the broad non-prescriptive nature of the current policy, the environmental community must develop methodologies for defining an initial set of

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[7]US Department of Defense, Department of Defense Instruction (DoDI) 5000.2, Defense Acquisition Management Policies and Procedures, (Washington D.C.: US Department of Defense, 23 February 1991), page 4-B-1 to 4-C-5.

pollution prevention objectives. These objectives can then be included in the trade-off process that occurs during demonstration / validation and ultimately results in a final set of detailed system requirements.

6.2.3 Cross-Disciplinary Teams

DoD strongly embraces the use of cross-disciplinary teams in its concurrent engineering approach to system design and engineering and every company visited is either using concurrent engineering or is in the process of implementing concurrent engineering system development processes. Based on these observations, the use of cross-disciplinary teams, or integrated product teams (IPT), now appears to be standard practice in the aerospace industry.

The IPTs are not necessarily effective in implementing pollution prevention, however. This results from three limitations that impact pollution prevention implementation that have been previously identified: 1) pollution prevention is not a design requirement, 2) design guidelines and tools do not address environmental issues in a useful way for designers, and 3) the necessary technical specialists within the company are not effectively integrated into the integrated product development process.

All three issues are implementation issues that do not require DoD policy changes. The first issue is the government's responsibility, the second issue is joint responsibility, and the final issue is the contractor's responsibility.

6.2.4 Environmental Impacts as Measures of Quality

This principle involves recognizing and including environmental indicators as measures of product quality. As with cross-disciplinary teams, DoD's strongly endorses the use of total quality management (TQM) principles and each company has a TQM-based quality program in place; however, the degree to which the TQM principles have been applied to environmental issues varies widely among the companies.

LFWC uses TQM principles extensively to manage its pollution prevention program. For example, the materials organization operates a permitted hazardous waste storage facility on-site which allows hazardous waste to be stored indefinitely, but LFWC has a goal to ship all hazardous wastes to a treatment facility within 60 days. In managing its hazardous wastes, each drum is tracked by waste type and the number of days in storage. Process control charts are used to track the program's status and are updated daily. Hazardous materials storage and use in LFWC's work areas are monitored by the Production Environmental, Health & Safety section. This two person operation is responsible for conducting self-audits of each work area, hazardous material storage area, and hazardous waste accumulation point quarterly. The self-audit results are summarized, tracked, plotted, displayed and briefed to management on a regular basis. Within LFWC's Environmental Resources Management (ERM) function, the company's environmental metrics, which are listed in Table 5.5, are tracked, updated, and displayed monthly, quarterly, and annually.

At P&W, hazardous waste generation records are kept for each waste stream and reports are issued to each manager for the manager's waste streams. This allows P&W to assign reduction goals to each manager and to track progress.

The examples show that some efforts are being made to track wastes as part of production, but that much more could be done using quality control tools to reduce wastes.

6.2.5 Pollution Prevention Principles Conclusions

Each of the four pollution prevention principles is being partially implemented in the programs studied. This has resulted in limited success in the pollution prevention efforts observed. Implementation of the life-cycle design principle has been given the least attention, although this approach is well established in DoD policy. Of the implementation issues presented, the lack of specific pollution prevention requirements is the only issue

that concerns government acquisition policies and procedures. The other issues are primarily the responsibility of contractors or concern technical tools that are needed and can be developed jointly.

6.3 System Design and Engineering

The second pollution prevention principle deals with the need to identify specific requirements. In systems acquisition, requirements serve as the interface between environmental concerns and the system design and engineering process. Requirements have this important property because recognizing the variable to be controlled and precisely defining it is the first of six steps needed to introduce a new variable into the system design and engineering process. The six steps, as presented by Coutinho,[8] are listed below:

1. Recognition of the variable to be controlled and its precise definition.
2. Development or selection of the methods of specification and of measurement, including the creation of an appropriate database.
3. Development of design control procedures.
4. Selection and performance of test applications.
5. Analysis of the test applications and determination of cost effectiveness.
6. Development of manuals and handbooks in support of general applications.

Reviewing the environmental requirements found in the system development contracts shown in Table 6.1 shows that only the requirements that meet the minimum criteria needed to write a system specification (steps one and two) are those in the jet engine contracts. This was further confirmed by reviewing the system engineering management documentation for each of the systems. In the programs studied, the only environmental requirements that have progressed as far as step three are noise and air emissions from jet engines at Pratt & Whitney, and systems engineering process associated with these requirements has met the criteria described in all six of Coutinho's steps.

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[8]John de S. Coutinho, Advanced Systems Development Management, (New York: John Wiley, 1977), 15.

For example, verification that air emissions requirements have completed all six steps can be done using P&W's F119 Propulsion and Power System Integrity Program (PPSIP) Master Plan[9] and the company's design guidance documents.

The PPSIP is a top-level planning document which summarizes P&W's engineering approach to the design, qualification, production, and life management of the engine. In section 5.2.7.4 of the PPSIP Master Plan, Volume II, design analysis for emissions and smoke are described. The section lists the specification requirements, the design success criteria, and the design methods that will be used to meet the criteria. The design verification methods for emissions are described in section 5.4.1.29 and include the test plan, resource requirements, test objectives, test description, success criteria, and data analysis.

Information for the final two steps is contained in P&W's design norms and in the company's design manuals for engine main combustors. The documents on these issues address the technical aspects of combustor design that impact combustor efficiency and emissions.

The successful incorporation of air emissions and noise requirements into P&W's systems design and engineering process shows that well defined environmental requirements can be managed on a systems basis. This challenges the government to do a better job of precisely defining the environmental variables it wants to control and to provide a means for measuring performance. Where this has been done, the technical tools for accomplishing system design will have been successfully developed and employed.

Figure 6.2 shows a design cube[10] that graphically shows some of the concepts included in Coutinho's first three steps for introducing a new variable into a system

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[9]Pratt & Whitney, "F119-PW-100 Propulsion and Power System Integrity Program (PPSIP) Master Plan," (Wright-Patterson AFB, OH: Aeronautical Systems Division, 1 February 1992), Contract F33657-91-C-0007, CDRL 8008.

design. Recognition of the variable to be controlled is shown on the reduction strategies axis. The context for measurement is shown on the product life cycle axis and design procedures are shown on the tools and methods axis.

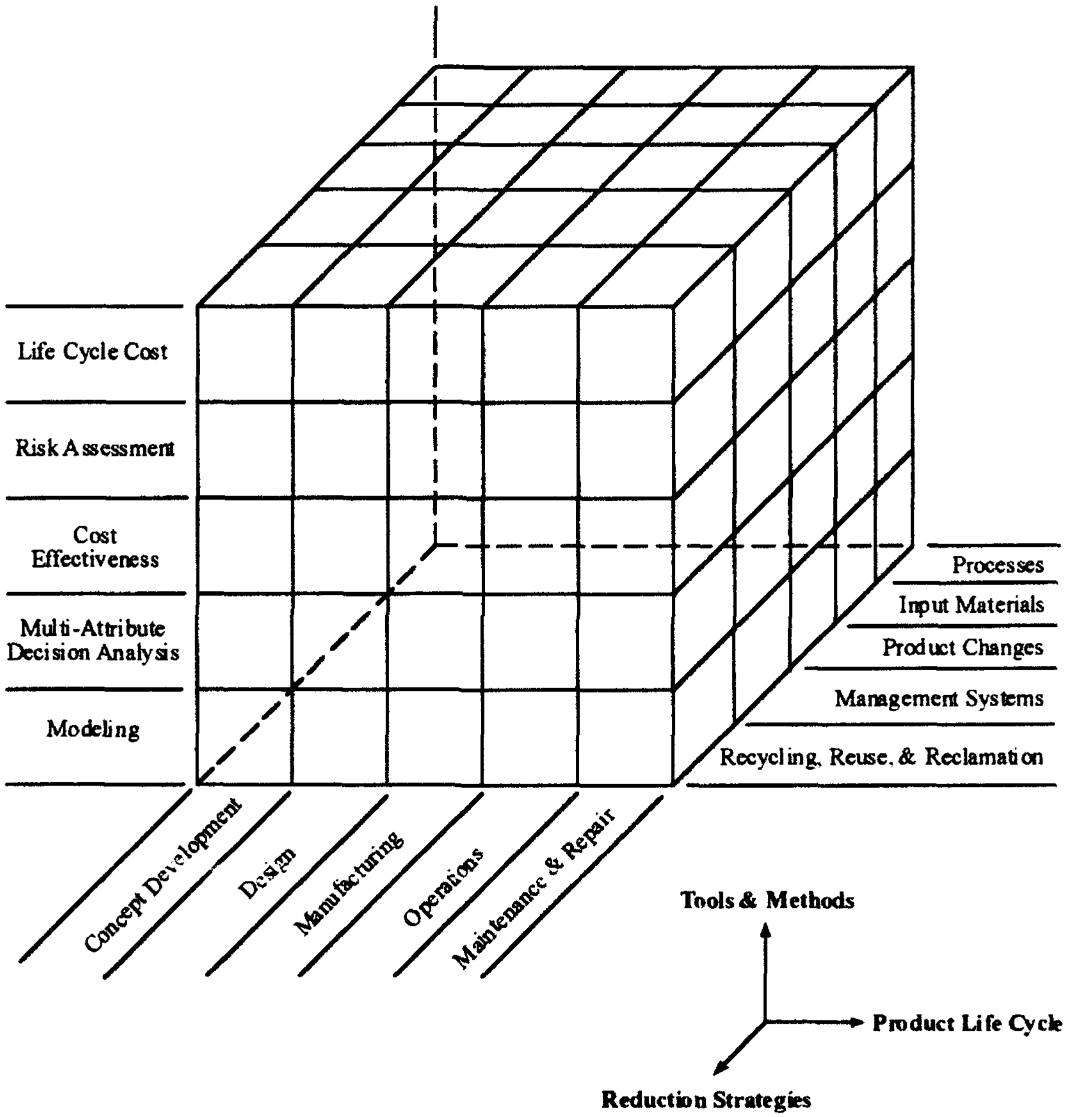

Figure 6.2. System Design Cube

[10]J.C. van Weenen and J. Eekels, "Design and Waste Prevention," The Environmental Professional, v. 11, 233.

The cube illustrates part of the complexity (only three dimensions can be shown) in introducing environmental variables into a system design. Note that cube expands on the product life cycle illustration used to display pollution prevention paradigms. Defining the product life cycle to be studied together with a reduction strategy (a starting point for analysis) is equivalent to selecting one of the paradigms shown in Figure 5.21. The tools and methods axis, shown vertically, illustrates the selection of one or more evaluation methodologies. This is the third step identified by Coutinho and it is also a component of all of the paradigms described in Chapter 5.

While the model in Figure 6.2 is useful, it is incomplete. Displaying all six of Continuo's steps would require a six-dimensional figure which is not easily shown. Although all of the relationships inherent in Coutinho's model are not shown in Figure 6.2, those that are shown illustrate that there is a clear conceptual link between the system design process, pollution prevention, and environmental impact assessment. The link revolves around the system boundaries that are defined for studying the problem. Pollution prevention analysis (PPA) primarily looks inward from the manufacturing or operating location boundary, while environmental impact analysis (EIA) is primarily concerned with looking outward. This relationship is illustrated at the end of the chapter in Figure 6.5.

6.4 Environmental Impact Analysis

Pollution prevention and environmental impact analysis (EIA), as required by the National Environmental Policy Act (NEPA), cover some of the same ground in that both attempt to identify actions that, if implemented, will reduce environmental impacts.

In Chapter 3, it was shown that pollution prevention can be fully integrated into systems engineering and design, while EIA, by Federal regulation, cannot. NEPA analysis supports high-level decision making on acquisition programs and is a government responsibility that cannot be delegated to the system contractor. Pollution prevention

involves both the government and the system contractor, and goes to the heart of the contractor's system design and engineering process.

This means that NEPA and pollution prevention are not interchangeable systems of analysis, but they are related systems. In Making Bureaucracies Think, Taylor argues that:

> . . .NEPA is an attempt to change the intelligence capabilities of the federal agencies--the kind of information they routinely develop and the weight they routinely give it in their decisions. . .[11]

To ensure a system of environmental analysis would provide the desired increase in organizational intelligence, Taylor identified eight generic "rules of analysis." The "rules" are derived from the methods science uses to advance knowledge and address both substantive and procedural issues.

1. Focus analysis on important issues.
2. Specify how much detail must be provided for various kinds of analysis.
3. Prevent the manipulation of alternatives to obscure the real choices available.
4. Facilitate helpful criticism by informed outsiders.
5. Provide forums for resolving technical disputes.
6. Adjust the burden-of-proof rules or distribution of analytical resources to make the system workable if the resources of outsiders and insiders are greatly out of balance.
7. Provide incentives for the analysis actually to be used in decision making.
8. Encourage continual improvement of analytical methodology.

Since integrating pollution prevention into the systems acquisition process requires the development of a closely related system of environmental analysis that is designed to improve decision making during system design and engineering, Taylor's rules provide a useful method for examining the policies and procedures that should apply to pollution prevention analysis in the systems acquisition process. In addition, since pollution prevention and NEPA overlap in the systems acquisition process, it should be possible for the pollution prevention and NEPA processes to complement each other.

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[11]Serge Taylor, Making Bureaucracies Think: The Environmental Impact Statement Strategy of Administrative Reform, (Stanford, CA: Stanford University Press, 1984), 3-4.

To address these issues, NEPA and pollution prevention implementation in system acquisition programs and in selecting military installations for bedding down new systems will be examined.

6.4.1 NEPA Implementation in Acquisition Programs

DoD Directive 6050.1 is DoD's top-level policy document for NEPA implementation, but it does specifically address acquisition programs. DoDI 5000.2 requires environmental analysis and planning[12] to begin at the earliest possible time in the acquisition process (during Phase 0, Concept Exploration and Definition), to look at the life cycle of the program, and for environmental effects to be identified in detail adequate to be integrated with economic and technical analysis for each alternative. Immediately after Milestone I, Concept Demonstration Approval, a programmatic environmental impact analysis is to begin. The programmatic analysis is tied directly to the National Environmental Policy Act regulations in the DoD policy:

> If a 'Finding of No Significant Impact' is proposed after completing a programmatic analysis or tier, the Program Manger will coordinate that document with the DoD Component official responsible for environmental programs. After coordination, the 'Finding' will be available to the pubic unless it is classified.
>
> When a programmatic analysis or a tier is completed in the form of an environmental impact statement, a Record of Decision will be prepared by the DoD Component for signature by the decisionmaker. . . Procedures are contained in Title 40, Code of Federal Regulations. Records of Decision are public documents unless classified.[13]

The results of the analysis are then summarized in a programmatic environmental assessment (PEA),[14] which must contain the following information:

1. A description of program being pursued,
2. The alternatives to be studied within the approved program,

[12]US Department of Defense, DoDI 5000.2, pages 6-I-1 to 6-I-6.

[13]Ibid., 6-I-5.

[14]Note that the PEA is not a formal NEPA document and it is not typically released to the public.

3. The potential environmental impacts of each alternative throughout the system life cycle,
4. Potential mitigation of adverse impacts, and
5. How the impacts and proposed mitigation would affect schedule, siting alternatives, and program cost.

DoDI 5000.2 also requires that the analysis occur regardless of the security classification of the program (the analysis carries the same security classification as the program), that the analysis be conducted simultaneously and be thoroughly coordinated and integrated with other plans and analyses, and that the analysis be updated. Each update of the analysis is called a tier and the tier focuses on the issues to be decided at that acquisition milestone.

Between June 1992 and April 1993, the DoD Inspector General (DoD IG) evaluated the effectiveness of the procedures described in DoDD 6050.1 and DoDI 5000.2. The IG found that DoD had not effectively integrated environmental management into the acquisition and budgeting processes for acquisition programs and that the Defense Acquisition Board, the body responsible for milestone decisions, did not adequately consider environmental issues. The IG also found that the services did not adequately involve the public, prepare and process environmental documents, fully assess the consequences, and integrate environmental life-cycle considerations into their decisionmaking processes.[15]

The IG's findings were similar to the conclusions reached in this research. In order to assess the information available to the Defense Acquisition Board, five examples of "good" programmatic environmental assessment (PEA) documents were obtained from the DoD staff. The documents are five to ten pages long and cover the required topics. The examples contain program information that would typically be found in the executive

[15]US Department of Defense, "Audit Report on Environmental Consequence Analyses of Major Defense Acquisition Programs," (Washington D.C.: US Department of Defense, Office of the Inspector General, June 1993), 13.

summary of an environmental impact statement (EIS) with the addition of relevant cost, schedule, and other program details that are not typically contained in an EIS.

One of the examples provided by the DoD staff was the programmatic environmental assessment (PEA) from the Joint STARS program. The PEA was used to support the production milestone decision for the system. Joint STARS is an airborne surveillance system that is installed in refurbished Boeing 707 aircraft that are purchased from commercial users. The program's PEA is six pages long and covers the alternatives considered, potential environmental effects, rationale for the concept/design alternatives chosen, and mitigation measures. Details on environmental impacts are discussed for Robins AFB, Georgia the selected base for the system, and at Grumman Aerospace Corporation, the prime contractor.

At Robins AFB, air quality, water quality, solid and hazardous wastes, and electromagnetic radiation are covered. For the first three areas, the incremental changes that would occurs if Joint STARS is based at Robins AFB are described. For electromagnetic radiation, threshold exposure levels are reviewed and mitigation actions are presented.

At Grumman, the company's compliance programs are described along with pollution prevention initiatives on dry paint stripping, reclamation of Freon 12 during flightline servicing, and a trade study on replacing the liquid transfer medium used in the Boeing 707's cooling system. The document concludes that, "Joint STARS poses no new or unique environmental and/or health hazards during development, manufacture and production, and the operation and maintenance of the system."[16]

The Joint STARS programmatic environmental assessment includes the required elements and it summarizes the first order and a few second order impacts of basing the

[16]US Air Force, "Integrated Program Summary, Annex E, Environmental Analysis for Joint STARS," (Washington D.C.: US Air Force, 1993), E-6.

system at Robins AFB, but it fails to discuss the full range of potential mitigation actions (pollution prevention) at either Robins AFB or at Grumman. For example, in discussing hazardous materials use at Robins AFB, the document states that the impacts are not expected to differ from those associated with depot level maintenance of existing systems. While this is probably true, it minimizes the importance of pollution prevention and avoids discussing the actions that could be taken. A new system should use significantly less hazardous materials and produce less wastes than systems produced years ago.

Comparing the Joint STARS programmatic environmental assessment and those from other programs, it is apparent that the purpose of the document is to defend proceeding to the next milestone, not to provide "unbiased" environmental analysis to members of the Defense Acquisition Board.

As a part of their audit, the DoD IG evaluated nine major programs. Two of the programs they evaluated were also studied in this research, the F-16 Fighting Falcon and the F-22 Advanced Tactical Fighter.

For the F-16, the IG concluded that the Program Office did not assess the environmental consequences for closing the chemical processing facility at Air Force Plant 4 (Lockheed Fort Worth Company) and they did not update program NEPA documents. The last F-16 NEPA environmental document was prepared in October 1976.

For the F-22, the IG found that the Air Force did not include environmental costs in the life-cycle cost estimate for the program, and did not file a Finding of No Significant Impact (FONSI) to the affected public and agencies as required by NEPA after the latest environmental assessment (EA) was completed in April 1991. The environmental assessment was used to support the program's Milestone II decision to proceed to engineering and manufacturing development (EMD).

The main issues discussed in the F-22 environmental assessment (EA) were the impacts of the EMD flight test program at Edwards, Holloman, Nellis, and Eglin AFBs. Manufacturing impacts on air and water quality were judged to be small. The EA

described the F-22's hazardous materials program for reducing hazardous material use and included a preliminary listing of hazardous materials that would be used in the system, but there was no indication of which materials would be used in the greatest quantities, which were the most toxic, or which would cause the greatest impacts. No specific data on manufacturing processes or pollution prevention options for reducing releases were presented.

While the EA met the requirements of the law, it could have done much more. It could have served as a planning vehicle for the Air Force to address strategic program-related pollution prevention goals and actions in a more specific and detailed manner. One way to do this would have been to examine the operational, maintenance, repair, and disposal releases and impacts from existing systems and identify common problem areas. Such an analysis could have served as the basis for focusing the document on both meeting the descriptive requirements of law as well as examining options for eliminating and mitigating potential impacts.

Finally, the DoD IG recommended that NEPA documents be prepared to support the critical design review that occurs during the engineering and manufacturing development phase of programs. They argued that at the critical design review, the program manager is asked to accept the design, materials, and manufacturing processes for the system and that it is the last opportunity to address many environmental issues without having to issue government directed changes to the program. The need for additional environmental analysis prior to a critical design review is clear, but whether formal NEPA-mandate environmental impact analysis can and should fill this role is a complex question because of procedural requirements that are inherent in the NEPA process. This issue is further analyzed in Section 6.4.3.1.

In summary, the NEPA-mandate environmental impact analysis process as implemented in acquisition programs does not include a requirement to fully describe

pollution prevention options, does not include public participation on a regular basis,[17] does not fulfill the need for programmatic environmental planning, and does not require on-going environmental analysis.

6.4.2 Implementation in Basing Decisions

In the last section, programmatic NEPA implementation was discussed. In this section, NEPA implementation in basing[18] decisions is reviewed. In this area, NEPA implementation is well established and there are generally accepted standards of analysis that have evolved from numerous NEPA cases that have been litigated in the courts.

To assess how pollution prevention issues are being handled, six Air Force NEPA documents were reviewed that supported recent basing actions. The documents are dated between March 1991 and February 1993 and include two environmental impact statements (EISs) and four environmental assessments (EAs). All of the documents follow a standard Air Force format that includes five chapters: 1) executive summary, 2) purpose and need for action, 3) description of the proposed action and alternatives, 4) description of the affected environment, and 5) environmental consequences.

In reviewing documents for pollution prevention issues, the first item that is quickly evident is the prominence, level of detail, and number of pages devoted to socioeconomic impacts, air emissions, and noise (air emissions and noise being the impacts most associated with flying). Table 6.2 shows the number of pages devoted to each of nine major categories of impacts in the documents reviewed. The number of pages shown represent the description of the impacts associated with the preferred alternative.

Recognizing that there is no "right" distribution of impacts, the table illustrates, and the text confirms that if the document has quantitative descriptions, maps, tables, or

[17]None of the acquisition environmental documents reviewed in Section 6.4.1 included a public participation process before the final documents were submitted.

[18]Decisions on selecting military bases for the beddown of new systems or the transfer of existing systems from other installations.

graphs, they are like to be associated with one of the top three categories. These results confirm what was observed in the environmental requirements of system contracts--air emissions and noise have long been issues with jet engine design and there are technical tools available to calculate and predict impacts in these areas.

Impacts	Pope AFB	37 TFW	Eglin AFB	Hill AFB	Nellis AFB	Luke AFB	%
Land Use	3	1	<1	3	1	4	9.2
Air Quality	11	4	1	1	<1	3	15.3
Noise Impacts	14	5	<1	1	<1	3	17.5
Airspace Management	9	2	<1	1	<1	<1	9.6
Socioeconomic	7	15	<1	1	1	10	25.8
Biological Resources	4	2	<1	1	<1	4	8.6
Water Resources	1	2	<1	1	<1	<1	3.6
Haz. Materials/Waste	3	2	<1	1	<1	<1	5.1
Archaeological, Cultural	2	2	<1	2	<1	<1	5.1

Table 6.2. Pages in NEPA Documents for Different Categories of Impacts

Looking at specific pollution prevention features in the NEPA documents, the environmental impact statement (EIS) for the, "Beddown of a Composite Wing at Pope AFB, NC," is typical. No pollution prevention actions are described for air emissions; biological resources; surface and groundwater; or archaeological, cultural, and historic resources. The EIS does describe standard Air Force procedures for minimizing noise in the vicinity of its bases. In addition, three pages are devoted to the introduction of hydrazine to the base.[19] Hydrazine is used as a fuel in the F-16's emergency power unit and the EIS describes the procedures that will be used to prevent hydrazine spills. No mention is made of any other maintenance procedures or of any other specific hazardous materials. Efforts to reduce volatile organic compound emissions are not covered nor are efforts to reduce wastewater and stormwater contamination.

[19]US Air Force, "Beddown of a Composite Wing at Pope AFB, NC," Final Environmental Impact Statement, (Langley AFB, VA: HQ Air Combat Command, 25 February 1993), 4-50 to 5-52.

In summary, none of the NEPA documents reviewed contained any pollution prevention recommendations that could be adopted by the program office for unique state compliance situations, for particular environments, or weapons system-wide. Based on these findings, one can conclude that the preparers of the NEPA documents were either not looking for pollution prevention and mitigation opportunities or were directed not to include them in final documents.[20]

6.4.3 Standards of Analysis

After proposing his set of eight "ideal" standards of analysis, Taylor compared the ideals with the court-articulated NEPA procedural requirements. He found that courts have enforced many procedural duties designed to make agencies develop, disclose, and use environmental analysis. On the other hand, he found that the burden-of-proof doctrine had not been altered to suit the needs of this policy area and that the courts do not provide an acknowledged forum for resolving technical issues.[21]

Of interest here is to what degree the system of environmental analysis now used in the acquisition process meets Taylor's ideals.

6.4.3.1 Focus on Important Actions

The Army and the Air Force have long accepted that the milestone decision points for major defense acquisition programs (MDAPs) would be treated as "major Federal actions significantly affecting the quality of the environment,"[22] triggering the NEPA process.

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[20]Note that base-level hazardous waste management plans and pollution prevention plans are full of prevention concepts and projects.

[21]Taylor, 90.

[22]National Environmental Policy Act, U.S. Code, vol. 42, secs. 4321-4361 (1970).

"Unlike the Army and the Air Force, the Navy uniquely interpreted that NEPA requirements are optional and are not applicable to its MDAPs."[23] The Navy argued that the requirements of DoDI 5000.2 can be satisfied by an environmental analysis that is not subject to the procedural requirements of NEPA.[24] This position sees the programmatic environmental assessment (PEA) required in DoDI 5000.2 as summary document unrelated to NEPA. To support this position, the Navy argued that under NEPA case law it is highly questionable whether a court would order DoD to prepare NEPA documentation at the early stages of an acquisition program. The Navy cited two key issues in determining when the NEPA obligation is triggered:

> First, has the agency developed a sufficiently defined 'proposal' for which it is preparing to make a decision that will 'irretrievably commit resources' in furtherance of the proposal. Second, will the action being proposed 'directly impact the physical, natural environment.'[25]

Based on the case law in this area, the Navy argued that the key triggering point is necessarily fact specific and can only be decided on a case-by-case basis. Thus, NEPA documents are not required at any specific points in all acquisition programs (i.e. milestone decision points), but NEPA is required at appropriate points as the facts of each program dictate. The DoD staff did not concur with the Navy's position and subsequently directed the Joint Standoff Weapon program manager to prepare the appropriate NEPA documents.[26]

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[23]US Department of Defense, "Audit Report on Environmental Consequence Analyses of Major Defense Acquisition Programs," 14.

[24]US Department of the Navy, Office of the Assistant Secretary, Research, Development, and Acquisition, "Draft Audit Report on the Review of the Joint Standoff Weapon Program as a part of the Audit of the Effectiveness of DoD Environmental Consequence Analysis of Major Defense Acquisition Programs," memorandum for the DoD Assistant Inspector General for Auditing, (Washington D.C.: US Department of the Navy, 18 June 1993).

[25]Ibid., Enclosure, 2.

[26]The point at issue, (does NEPA apply to all major defense acquisition program milestone decisions) has not been directly litigated.

This exchange resolved the Joint Standoff Weapon case, but DoD's letter to the program manager does not apply to other programs. In order for the decision to become DoD policy, a more general statement is needed that directs all program managers to conduct the appropriate NEPA analysis prior to milestone decisions. In addition, the programmatic environmental assessment (PEA) required in DoDI 5000.2 is not a NEPA document. Neither the Federal regulations nor DoD regulations on NEPA define a PEA. Either the term should be dropped and standard NEPA language used, or the PEA's purpose, relationship to NEPA documents, and preparation criteria should be defined.

A second issue that was raised in the DoD IG audit concerns application of NEPA to acquisition decision points that are delegated to the program manager and are not routinely reviewed by the DoD or service staffs. Specifically, the IG recommended a NEPA document be prepared to support the critical design review (CDR) that occurs during engineering and manufacturing development (EMD) phase of a program. At the CDR, the government accepts the contractor's technical recommendations on design, materials, and manufacturing processes.

Table 6.3[27] shows the key events in the design process that lead to the preliminary design review (PDR) and the critical design review (CDR). While conducting an environmental review at CDR may seem to be a reasonable requirement, it would probably accomplish little. At the CDR, the contractor and government are working to bring the program's technical design issues to closure. This includes looking at the program's environmental issues. The contractor's task at the CDR is to "convince" the program manager that the requirements have been met. The core of the process is assessing the contractor's compliance with the contract specifications. In a civilian agency, this would be like preparing a NEPA document to support a 70% design review for a highway, dam, or other development project. A practice that has not been required.

[27]US Department of Defense, DoDI 5000.2, page 5-B-2.

Design Events
Design Policy
Design Requirements
System/Subsystem Architecture
Preliminary Schematics/Layout
Software Preliminary Design
Preliminary Physical Design
Software Detailed Design
Preliminary Design Review
Design Rules and Guidelines
Software Code Inspections
Physical Design vs Requirements
Analyses (functional, thermal, electrical, power, reliability, etc.)
Product Drawings & Associated Lists
Testing (software module, integration, system)
Installation & Field Manuals
Critical Design Review
Testing and Final Design

Table 6.3. Acquisition Design Events

Even though there may not be a NEPA requirement associated with a CDR, is there a logical reason for a NEPA-like review at CDR? Once again the answer is probably no. From a practical point of view and given the contract management focus of a CDR, it is not an appropriate point in the acquisition process for public input. In addition, the CDR occurs well into the design process and pollution prevention issues are better considered at an earlier point. From a technical point of view, the programmatic NEPA documents do not include the level of detail needed to provide meaningful input at a CDR.

Looking at the overall acquisition process, there are at least seven key events for pollution prevention during the acquisition process:

1.	Milestone I	Start of demonstration/validation
2.	Milestone II	Start of engineering and manufacturing development (EMD)
3.	EMD	Design requirements
4.	EMD	Preliminary design review
5.	EMD	Design rules and guidelines
6.	EMD	Critical design review
7.	Milestone III	Start of production

At Milestone I, pollution prevention objectives for the program must be set. At Milestone II, pollution prevention requirements must be set for EMD. Defining design requirements involves allocating pollution prevention requirements to specific subsystems, components and parts of the system. At PDR, the contractor reviews all of the criteria associated with the design events that precede the PDR. A review at this point, unlike at CDR, allows time within the program schedule to address issues that are not being appropriately considered. The development of design rules and guidelines formalizes how pollution prevention will be included in detailed design. At CDR, the events following PDR are reviewed. Finally, at Milestone III, pollution prevention issues associated with basing actions should be the focus of analysis.

Given these key events and the fact that environmental analyses are already required at the milestones, an analysis at the PDR make more sense than at CDR, but probably even more important is the need for on-going environmental analysis at the program office during the development process.

6.4.3.2 Specify the Level of Detail

Taylor framed this principle with the question, "What level of detail should there be, and for what ultimate purpose?"[28] These are critical questions in trying to understand what role NEPA analysis can and should play in implementing pollution prevention in the systems acquisition process.

The output of a NEPA analysis is a categorical exclusion (CATEX), an environmental assessment (EA), or an environmental impact statement (EIS). When an EA or EIS is prepared, it must explain three key decision elements: 1) the need for an action, 2) descriptions of the proposed action and the alternatives, and 3) the environmental consequences of implementing the action or an alternative.

[28]Taylor, 76.

In the NEPA documents reviewed, the level of detail was inadequate for addressing pollution prevention. This occurred because the documents focus almost exclusively on describing the physical and other impacts for each alternatives at specific locations. For pollution prevention, the more important issues concern "internal" design alternatives within each of the global alternatives. Another way of looking at this issue is to consider NEPA as a macro-level analysis for studying the potential impacts of different global alternatives and pollution prevention as a micro-level analysis that looks a different ways to minimize pollution within global alternatives. For NEPA to be an effective tool for addressing pollution prevention, it must address internal pollution prevention alternatives as well as global alternatives.

6.4.3.3 Prevent Manipulation of Alternatives

This principle is usually concerned with which "global" alternatives to the proposed action are to be considered. In the acquisition process there are usually two global alternatives: 1) to proceed to the next step in development, or 2) to cancel the program. This makes systems acquisition fundamentally different from most development decisions where the "no action" alternative often provides a baseline for analyses of the other alternatives. Except at Milestone 0, the no action alternative does not have the same meaning and often does not make sense in an acquisition program. Often the no action alternative is defined to be the same as a decision to cancel the program. This is not the same as "no action" in a development project. In any case, whether a decision is made to proceed, to delay (the real no action alternative), to cancel, or restructure, the decision will have political and socioeconomic impacts and usually involves environmental impacts as well. Given the nature of an acquisition milestone decision, the global alternatives to be studied are not usually at issue.[29] Neither is segmentation an issue. Segmentation occurs

[29]This is not always the case; however, especially with strategic systems such as nuclear submarines, intercontinental ballistic missiles, and other very expensive systems.

when an agency divides a large complex program in a series of smaller projects for presentation. The very nature of the acquisition process, line item budgeting, and intense Congressional oversight usually prevent segmentation of acquisition programs.

6.4.3.4 Facilitate Criticism

Among NEPA's most important features are its provisions for public input and comment. Public input usually occurs early during the NEPA process during scoping and again later during the comment stage of the process. Often the first point in a NEPA analysis for public input occurs during scoping, an early and open process for determining the scope of the issues to be addressed, for identifying the significant issues, and for eliminating from study those issues that are not significant.

In systems acquisition, scoping meetings are very rare for the NEPA analysis associated with acquisition Milestones I and II. This arises from the fact that an environmental assessment (EA) is prepared for most systems which leads to a finding of no significant impact (FONSI), without a public comment period. While there is no requirement to hold scoping meetings, they are commonly used when an environmental impact statement (EIS) is being prepared, but almost never employed when an EA is prepared. Thus, by preparing EAs with no scoping meetings and without a public comment period on a draft document, there is little opportunity for public input or comment in the systems acquisition process.[30]

The DoD IG[31] reached the same conclusion when it reviewed Army and Air Force NEPA implementation saying, "We also found that the decisionmaking process did not

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[30]There are several highly controversial programs that are exceptions to this. Examples include the MX missile of the late 1970s and the GWEN communications system of the 1980s. Note that in both cases most of the dicussion centered on basing issues which were central to the design of the systems. These are unusual cases. In most acquisition programs, initial basing decisions are not usually made until well into the engineering and manufacturing development phase of the program.

[31]US Department of Defense, "Audit Report on Environmental Consequence Analyses of Major Defense Acquisition Programs," 14.

include public involvement." If basing is not an issue, there are usually few issues raised in the NEPA documents. Impacts at the locations where the system will be developed and tested are presented, but these impacts are almost always described as being relatively small and are usually insignificant to the milestone decision. Since the macro-level impacts are typically small and micro-level pollution prevention issues are not discussed, the programmatic environmental assessment (PEA) carries no weight in the decision process.

For most systems, the micro-level pollution prevention objectives, requirements, trade-offs, and goals, are the most important environmental issues early in the development effort. This situation arises because it is impossible to predict ultimate site specific environmental impacts when neither the manufacturing sites nor the operating locations for the system are yet known.

If the application of NEPA is expanded to address pollution prevention, it could be a useful environmental process for developing and publicly reviewing programmatic pollution prevention objectives. In this process, scoping would be important for helping to establish what pollution prevention issues should addressed in Milestone I and II decisions.

6.4.3.5 Provide Forums for Resolving Technical Disputes

In reviewing the case law on NEPA, Taylor concludes that the courts have generally taken the position that they should not attempt to resolve scientific disputes in NEPA cases.[32] This is primarily due to the fact that such cases present factual rather than procedural issues, and the courts traditionally afford substantial deference to agency determinations of fact.[33] With the courts generally not willing to review factual disputes, NEPA does not have a good internal mechanism for resolving technical disputes.

[32]Taylor, 84.

[33]NEPA Deskbook, (Washington D.C.: Environmental Law Institute, 1992), 23.

From a public perspective, the situation is even worse in the systems acquisition process where many program details are classified and where many programs meet the NEPA requirement without ever obtaining public comments by using an environmental assessment rather than an environmental impact statement. In the acquisition process, Congressional oversight and the political process provide the means most often used for addressing technical issues.

6.4.3.6 Adjust the Distribution of Analytical Resources

In NEPA cases, environmentalists that allege inadequate analysis by the agency must make their case by the preponderance of evidence, a doctrine that shows so special regard for the balance of resources between citizen groups and the agency.[34] Taylor argues that the burden-of-proof rules should be adjusted to compensate for the citizen's lack of resources compared to the agency. This provides a means to adjust the distribution of analytical resources between the public and the government.

Since NEPA's role in systems acquisition process has been subject to so little litigation, the distribution of analytical resources between the public and the government has not been an issue. The more important distribution of analytical resources concerns the distribution within the agencies.

In studying the U.S. Army Corps of Engineers and the Forest Service in early 1980s, ten years after NEPA became law, Taylor found that the number of environmental analysts had increased several fold and that the analysts had generally been integrated into an interdisciplinary planning process. While this is probably true for the development activities of the Navy and Air Force as well as the Army, environmental analysts have never been integrated into the system acquisition community of the Air Force. The DoD

[34]When NEPA documents are reviewed for adequacy, they are usually reviewed under the Administrative Procedure Act standard for review of agency actions: an agency action is to be set aside if found to be arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law.

IG commented on the facilities orientation of the environmental activities of the services noting:

> Environmental planning within DoD has been traditionally oriented toward operation of facilities and installations, with emphasis on pollution control. . . The military departments have placed responsibility for the implementation of NEPA under the environmental and civil engineers. . . Further, the military departments did not establish a means for the environmental engineers and the acquisition community to exchange information. . .
>
> . . .The requirements are often interpreted as applicable to weapon system acquisition only as they impact facilities and installations. 'Facilities' is usually viewed by the program offices as a collateral responsibility assigned to a logistics staff-person. Designating this function as a secondary responsibility not only adversely influences the attention given to the function but also impacts the dissemination of information concerning environmental guidance and requirements.[35]

None of the programs studied in this research have a full-time environmental professional within the program office. Among the programs studied, the F-22 has the largest program staff numbering several hundred. Throughout the demonstration-validation phase of the program and early in engineering and manufacturing development, the program's environmental issues were handled on a part time basis by one or more persons in the system safety office. Over the past two years the environmental work load has increased to the point that one of the safety engineers now works full-time on environmental issues.

Until 1992, the Air Force program offices at Wright-Patterson AFB were supported by a small environmental staff of two to five people that worked for the Aeronautical Systems Center's (ASC) Civil Engineer and by a like number of Bioenvironmental Engineers (industrial hygiene professionals) that were assigned to the ASC system safety office. The environmental professionals performed two primary tasks, supervising contractors hired to prepare NEPA documents for the programs and overseeing the

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[35]US Department of Defense, "Audit Report on Environmental Consequence Analyses of Major Defense Acquisition Programs," 27-28.

environmental cleanup activities at Air Force Plants. In this capacity, the environmental professionals were little more than "temporary consultants" to the program offices for as long as it took to prepare the needed NEPA documentation.

In 1992, ASC created an interdisciplinary pollution prevention office which has now grown to over 50 people. These professionals are responsible for central planning and are also assigned, using a matrix organizational approach, to work with the larger program offices on a part-time basis. Thus, what Taylor observed concerning the integration of environmental analysts in the development agencies in the early 1980s, is only now beginning to occur in the Air Force acquisition community. The ultimate impact of this belated integration of environmental professionals will start to become clear in a few years.

6.4.3.7 Provide Incentives to Use the Analysis

As the NEPA regulations note, NEPA's purpose is not to generate paperwork--even excellent paperwork--it is better decisions that count.[36] Taylor found that the courts confronted the issue of *pro forma* compliance (of a very unsophisticated kind) early on and declared that more was intended by the statute. In reviewing the tests that courts have applied to deciding these cases, he noted that only the grossest lack of consideration would be caught.[37] In recent years, (1978, 1983, 1985, & 1989) the Supreme Court[38] has limited, but not completely foreclosed substantive review of agency decisions declaring that NEPA's mandate is essentially procedural.[39]

Since the courts are unlikely to intervene in the acquisition process, internal DoD policy is needed to encourage the use of environmental analysis in decision making.

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[36]NEPA Regulations, 40 Code of Federal Regulations, sec 1500.1.

[37]Taylor, 85-87.

[38]For the most recent decision, see Robertson v. Methow Valley Citizens Council, 57 U.S.L.W. 4497, 5401-02, 19 ELR 20743, 20746-48 (U.S. May 1, 1989).

[39]NEPA Deskbook, 23.

6 4.3.8 Encourage Continual Improvement

This is one of the central issues Taylor explores throughout his book--how can the government learn under conditions of conflict? The government is responsible for protecting the environment, but government agencies all too often cause environmental damage as a "side effect" of their enthusiastic pursuit of programmatic goals.[40] This conflict is basic to implementing pollution prevention in acquisition programs.

On a practical level, the courts have addressed the issue of forcing an agency to use a new method of analysis in preparing a NEPA document. In looking at this, Taylor found that before an agency can be forced to improve its methodology, plaintiffs must show that a new technique is available and presumably also that significantly different results may be expected from its use.[41]

In the review process that precedes acquisition milestone decisions, the technical contents of the various Annexes to the Integrated Program Summary are reviewed by the DoD staff. This central review process[42] provides the DoD environmental staff with the opportunity to review the environmental analysis contained in the programmatic environmental assessment (PEA), and to insist that the "best" methods of analysis be employed. Another mechanism for improvement over time occurs when the staff provides "samples" of good analysis to the environmental analysts in programs with pending reviews.

6.4 4 Environmental Impact Analysis Conclusions

The EIA process required by DoDI 5000.2 as it is being implemented is shown graphically in Figure 6.3. The figure illustrates a historical implementation of the

[40] Taylor, 3.

[41] Taylor, 90.

[42] This highly centralized and standardized systematic review process is unique to acquisition programs. For development projects within the DoD, the only documentation from the NEPA process that is routinely seen at DoD is a single page certification that the requirements of NEPA have been satisfied.

environmental impact analysis (EIA) process that is principally concerned with predicting the site-specific environmental impacts that are associated with the selecting operating bases for deploying new systems. Unlike the Government's experience in conducting EIA for development projects, where environmental planners have become part of the planning process, EIA has never become an integrated part of the systems development process in the Air Force. This understanding of the EIA process is borne out in the EIA documents reviewed earlier, the relatively small number of environmental professionals in the development organizations, and their placement outside the program offices. As a result of these problems, the EIA process in systems acquisition has three major limitations: 1) EIA is an add-on process, 2) EIA is not continuous, and 3) EIA is too focused on site-specific impacts.

The add-on nature of EIA is depicted in Figure 6.3, where the EIA process is shown on the left-hand side of the figure. EIA starts during Milestone 0, with an Initial Environmental Analysis (see block 1). The results of this analysis are used to support the Milestone I decision process. DoDI 5000.2 assumes that the nature of the Milestone I decision to start Demonstration/Validation does not trigger NEPA implementation. This interpretation is based on the descriptions of the Initial Environmental Analysis and of the Programmatic Environmental Assessment (PEA) in DoDI 5000.2. The description of the Initial Environmental Assessment makes no mention of NEPA or the NEPA regulations while the description of the programmatic environmental assessment (PEA) is very clear that NEPA must be satisfied:

> The programmatic environmental assessment will begin immediately after Milestone I, Concept Demonstration Approval, in accordance with Title 40, Code of Federal Regulations (reference b). . .[43]

[43]US Department of Defense. DoDI 5000.2, page 6-1-4.

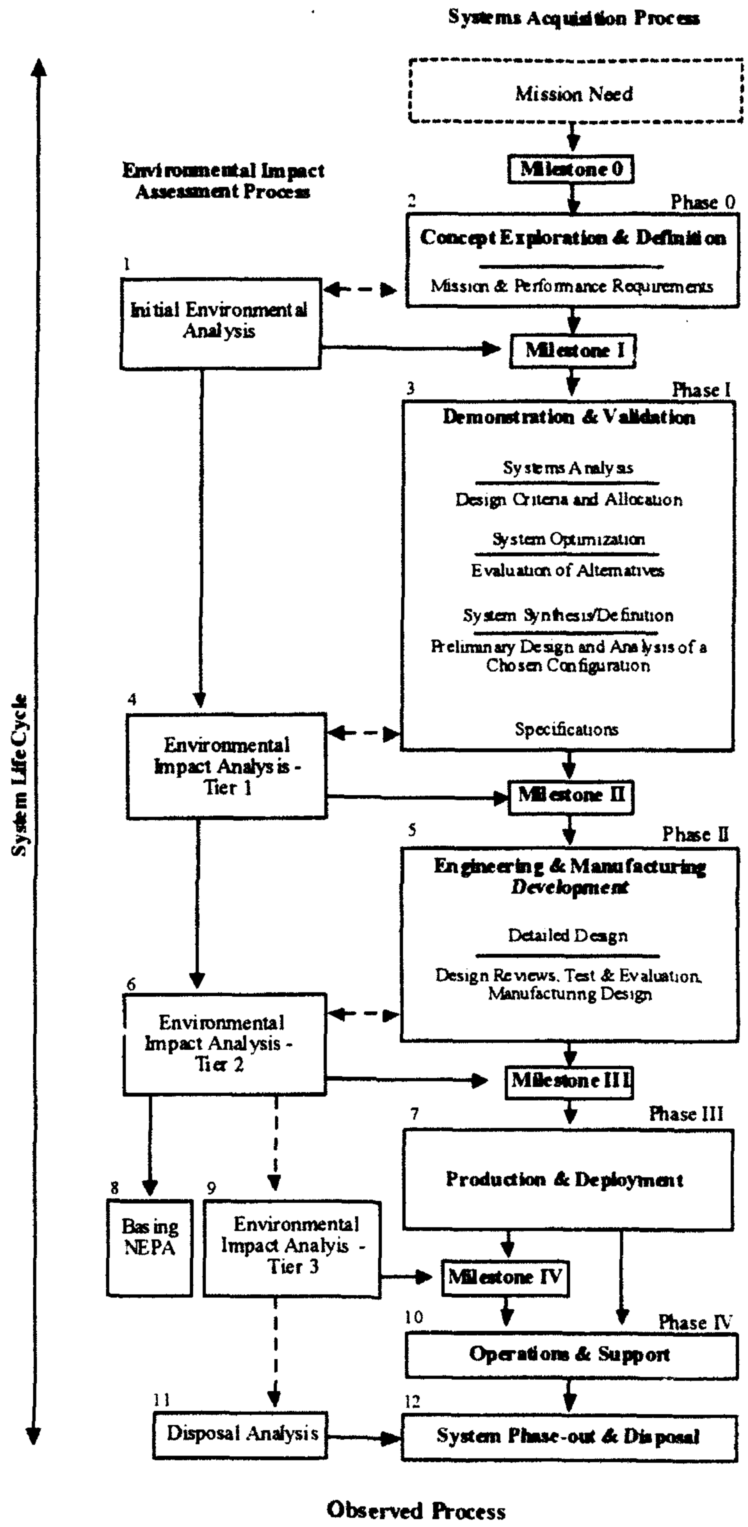

Figure 6.3. Observed Environmental Impact Analysis Process

Reference b refers to Title 40, Code of Federal Regulations, Parts 1500-1508, "National Environmental Policy Act Regulations." Thus, the PEA is clearly intended to be based on a NEPA-driven environmental analysis process. This policy language seems to indicate that generic EIA is different than a NEPA-driven environmental analysis. This differentiation helps reinforce a system of NEPA analysis that is undertaken as a separate, add-on, system of analysis.

Another factor that has fostered the development of NEPA analysis as an add-on system of analysis involves the number and organizational placement of the government's environmental specialists. The EIA process is usually supervised by a small environmental staff that is not part of the acquisition program, but instead, provides a core support function at a product center such as the Air Force's Aeronautical Systems Center (ASC). The actual assessment is usually contracted out to a firm experienced in conducting EIA for the military where the firm's "experience" is usually in conducting EIA for development projects.

At Aeronautical Systems Center, a handful of environmental specialists have been supporting over \$20 billion per year in aircraft procurement. The Air Force facilities community, on the other hand, is responsible for development projects funded through the Military Construction Program and for facilities maintenance and repair. To accomplish this facilities mission, the Air Force's fiscal year 1993 budget included approximately \$6 billion, but employs over 1800 environmental specialists.

Thus, as a result of the small number of environmental specialists and their organizational placement, environmental specialists have never been integrated into the acquisition process. This has limited the role of EIA in the process to occasional contractor-prepared NEPA documents that were needed prior to the milestone reviews. This is a fundamental problem.

In applying EIA to development projects, Wathern has stated, "The greatest contribution of EIA to environmental management may well be in reducing adverse

impacts before proposals come through to the authorization phase.[44] In systems acquisition, this opportunity to prevent pollution has largely been lost.

Wathern's description of an authorization phase for development projects points to another aspect of the systems acquisition process that is different than all but the largest development projects. Acquisition programs undergo an annual authorization phase. For most Military Construction Program projects (Air Force development projects), each item is presented to Congress once, and the total funding needed for the construction is provided in one year's authorization and appropriation bills. To support the authorization process, a brief summary of each project's environmental impacts is submitted to Congress.

In systems acquisition, an EIA summary document is not needed to support the annual authorization process, thus, the EIA process and the authorization process are uncoupled. This also occurs for large development projects that receive annual funding.[45] This uncoupling of the EIA process from the authorization process is another factor in the evolution of EIA as an add-on process in system development.

Summarizing, the evidence for EIA as an add-on process in Air Force systems acquisition includes the implemented EIA process, the EIA documents, and the number and organization placement of environmental specialists in the systems acquisition process. All three factors point to the fact that the Air Force has not integrated EIA into the systems acquisition process. Because of this, the benefits of having an integrated EIA process have not been realized.

The second major limitation of EIA in systems acquisition is that EIA process is not continuous. In Figure 6.3 the EIA process is represented as a discrete, non-continuous

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[44]Peter Wathern, "An Introductory Guide to EIA," in Environmental Impact Assessment. Peter Wathern, ed.. (London: Unwin Hyman, 1988) 6.

[45]A recent example was the Department of Energy's Super-Conducting Super Collider (SSC) project in Texas that was canceled due to high cost.

system of analysis that takes place immediately prior to the decision milestones. Note the location and size of blocks 1, 4, 6, 9, and 11. This is consistent with the way EIA is being implemented in the programs studied.

In describing the decision process that leads up to the authorization phase, Wathern points out that:

> Over the years, it has become increasingly evident that the authorization of proposals is not the sole decision point. There are many decision makers involved in the evolution of a set of development proposals and the influence of most of them is exerted long before the submission of an application for formal project authorization.[46]

Wathern's view of the development process clearly involves both macro and micro environmental analysis components where many potential impacts are identified and addressed during the planning and design phases of a program, long before the formal EIA documents are prepared to support the authorization phase. This description of a more-or-less continuous decision process is the very essence of the system engineering process used in acquisition programs. Wathern assumes that EIA results in an informal, continuous, micro-focused EIA process that produces these "unseen" benefits. This research indicates that while this maybe true for development projects, it is not true for acquisition programs.

DoDI 5000.2 states that the environmental analysis will start "immediately after Milestone I," indicating that the environmental impact analysis (EIA) process should extend throughout Phase I of the program, but this has rarely occurred. If the EIA process were continuous, it would be represented by extending the length of the EIA blocks to correspond to each phase of the program. This "ideal" EIA process is illustrated in Figure 6.4.

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[46]Wathern, 6.

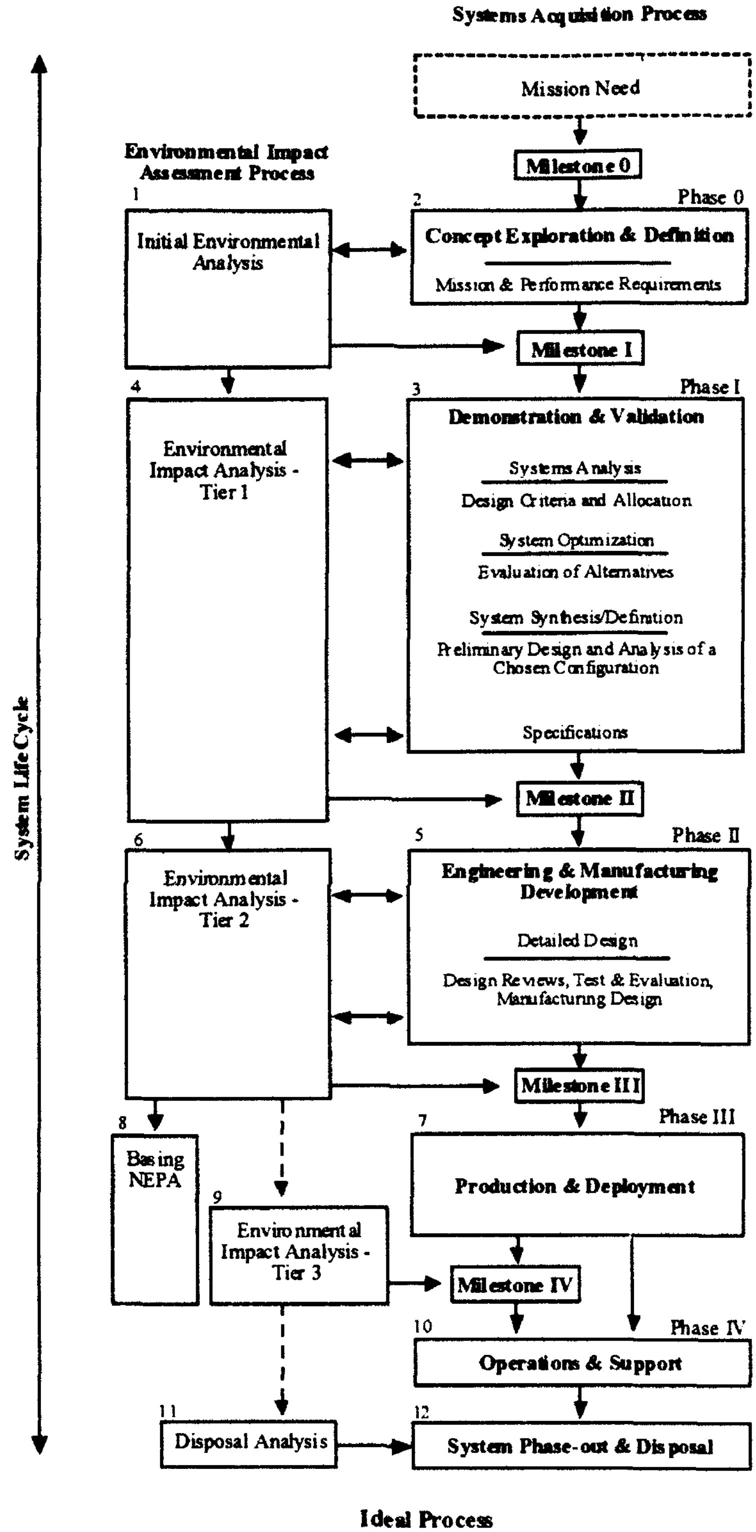

Figure 6.4. Ideal Environmental Impact Analysis Process

The dotted lines in Figure 6.3 and Figure 6.4 indicate information exchange. The solid arrows indicate that the activities are directly linked in the acquisition decision process. If the EIA process were fully integrated with the acquisition process, Figure 6.3 would show this with solid arrows between the lengthened EIA blocks and each of the acquisition process blocks, as is shown in Figure 6.4. In the programs reviewed for this research, the EIA process was implemented as a semi-independent process with minimal interface with the acquisition process, except for a short period immediately prior to a milestone decision.

Thus, Figure 6.3 represents the way EIA is currently implemented, and it will be assumed that Figure 6.4 represents the way the writers of DoDI 5000.2 intended EIA to be implemented. Given the NEPA requirement for EIA and that DoD both desires and is required by Executive Order 12856[47] to implement pollution prevention, vastly different processes for implementing pollution prevention are possible. The implications of this will be analyzed in Chapter 7.

The third limitation impacting EIA implementation involves the NEPA requirement for impact assessment. Figure 6.5 shows the life cycle of a system. The scope of NEPA environmental impact analysis process as it should be implemented is shown at the top of the figure. The actual NEPA process as implemented in systems acquisition is illustrated in the oval in the middle of the figure. The aircraft in the circle is symbolic of the focus of the acquisition NEPA process which is focuses on describing the impacts associated with operational use of the system. For jet aircraft, the impacts associated with the system are air emissions and noise. At the same time, the industrial processes associated with manufacturing and with maintenance and repair of the system are given minimal attention

[47]President Clinton signed Executive Order 12856, "Complying with Community Right-to-Know Laws and Pollution Prevention Requirements," on 3 August 1993. The executive order has over 40 separate requirements, one of which, requires each Federal agency to. "Establish a plan and goals for eliminating or reducing the unnecessary acquisition by that agency of products containing extremely hazardous substances or toxic chemicals" [Section 3-303(a)].

in the documents reviewed. This is shown in the figure by the fact that the industrial processes (along with serious consideration of design and manufacturing and maintenance and repair) are outside the oval that highlights the focus of the acquisition NEPA process. The scope of pollution prevention is shown at the bottom of the figure.

System Life Cycle

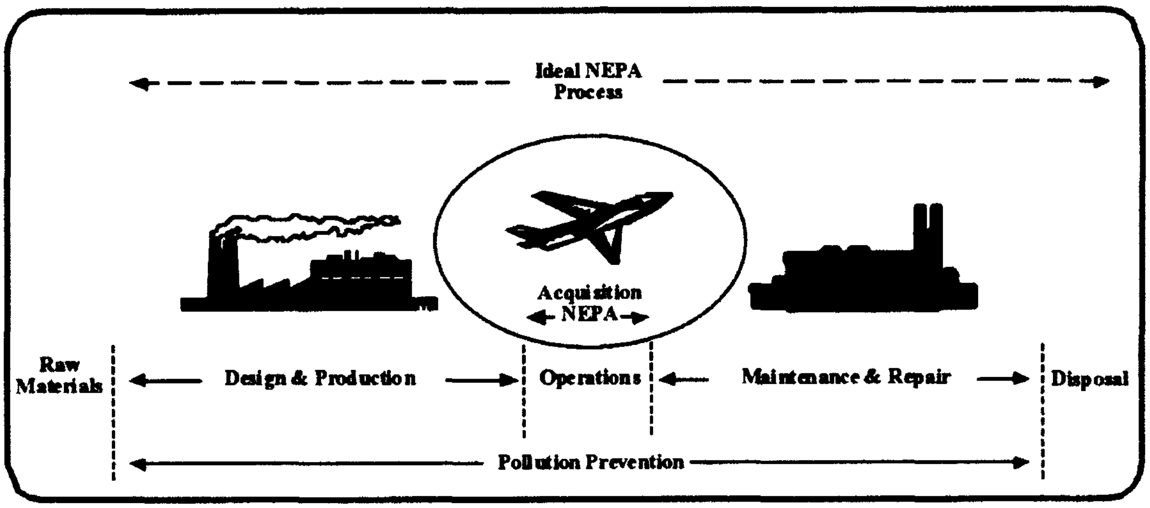

Figure 6.5. Environmental Impact Analysis and the System Life Cycle

Environmental impact analysis (EIA) can be described as a process for identifying the likely consequences for the biogeophysical environment and for man's health and welfare of implementing particular activities and for conveying this information to the decision maker at a stage when it can materially affect the decision.[48] The environmental consequences, or impacts, have both spatial and temporal components and can be described as the change in an environmental parameter, over a specified period and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been undertaken.

[48]Wathern, 6-7.

This view of the EIA process presents one of the key limitations in implementing EIA in the systems acquisition process. Since manufacturing locations and basing sites are unknown early in the acquisition process, it is nearly impossible to assess the spatial component of potential environmental impacts until well into the EMD phase of most programs. Because of this, information that can materially affect early program milestone decisions is rarely developed in the DoD's current EIA implementation.

In order to try to address impacts, each of the acquisition NEPA documents reviewed, treated the design of the system as a fixed variable, and the analysis proceeded to estimate the impacts that would result by varying the testing or basing variables. Pollution prevention analysis[49] (PPA) documents, on the other hand, largely ignored testing and basing issues and addressed manufacturing, operations, maintenance and repair issues associated with program design choices for materials, processes, or other variables.

Another important difference between PPA and EIA that was observed is that PPA was almost always based on analyzing wastes or releases instead of impacts. In PPA, wastes and releases are considered as environmental quality indicators. EIA, on the other hand, tried to deal with impacts and almost never reported indicator variables. None of the NEPA documents reviewed listed hazardous material uses or releases, hazardous wastes, or wastewater volumes for either the baseline condition or under any of the alternatives--yet the impacts from these hazards were always "judged" to be small. Thus, while the analysis methods seem to be very similar conceptually, in practice, the methods as used in the Air Force, have developed into very different systems of analysis. To correct these problems, DoD policy should be revised to address pollution prevention, and the relationship between the programmatic environmental assessment, NEPA environmental impact analysis, and pollution prevention.

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[49]Pollution prevention analysis is defined to mean an on-going, micro-focused system of environmental analysis the fill the void in environmental analysis in current acquisition programs.

6.5 Acquisition Pollution Prevention Process

Implementing the concepts developed in the pollution prevention implementation framework requires a basic pollution prevention process within the systems acquisition process that does not now exist. As a first step in developing a more comprehensive understanding of how environmental impact analysis (EIA), pollution prevention analysis (PPA), and systems engineering can work together, a basic PPA process is suggested.

The PPA process is adapted from a general process for logistics support requirements developed by Blanchard.[50] A key feature of this representation is its breakdown of Phase I of the acquisition process into multiple activities. Blanchard did this in recognition of the importance to cost and schedule of early identification of logistics requirements. Based on similar arguments made for pollution prevention in Chapters 2 and 3, this structure is retained for conceptualizing the PPA process. To help identify the various parts of the PPA process, the following descriptions refer to the block numbers shown on the top-right side of the process blocks in Figure 6.6.

<u>Blocks 1 and 2</u>. Given a specific need, the system operational characteristics, mission profiles, deployment, utilization, effectiveness figures of merit, maintenance constraints, operating environment, and environmental compliance constraints are defined. Using this information, the system pollution prevention concept is defined, and a system level specification is developed.

<u>Blocks 3 and 4</u>. Major operational, test, production, and support functions are identified, and qualitative and quantitative requirements for the system are allocated as design criteria (or constraints) for significant levels of the prime equipment as well as applicable elements of support (i.e., test and support equipment, facilities, etc.). Those requirements that include environmental factors also form boundaries for the design.

[50]Benjamin S. Blanchard, <u>Logistics Engineering and Management</u>, 4th ed., (Englewood Cliffs, NJ: Prentice Hall, 1992), 7.

Pollution Prevention in the System Life Cycle

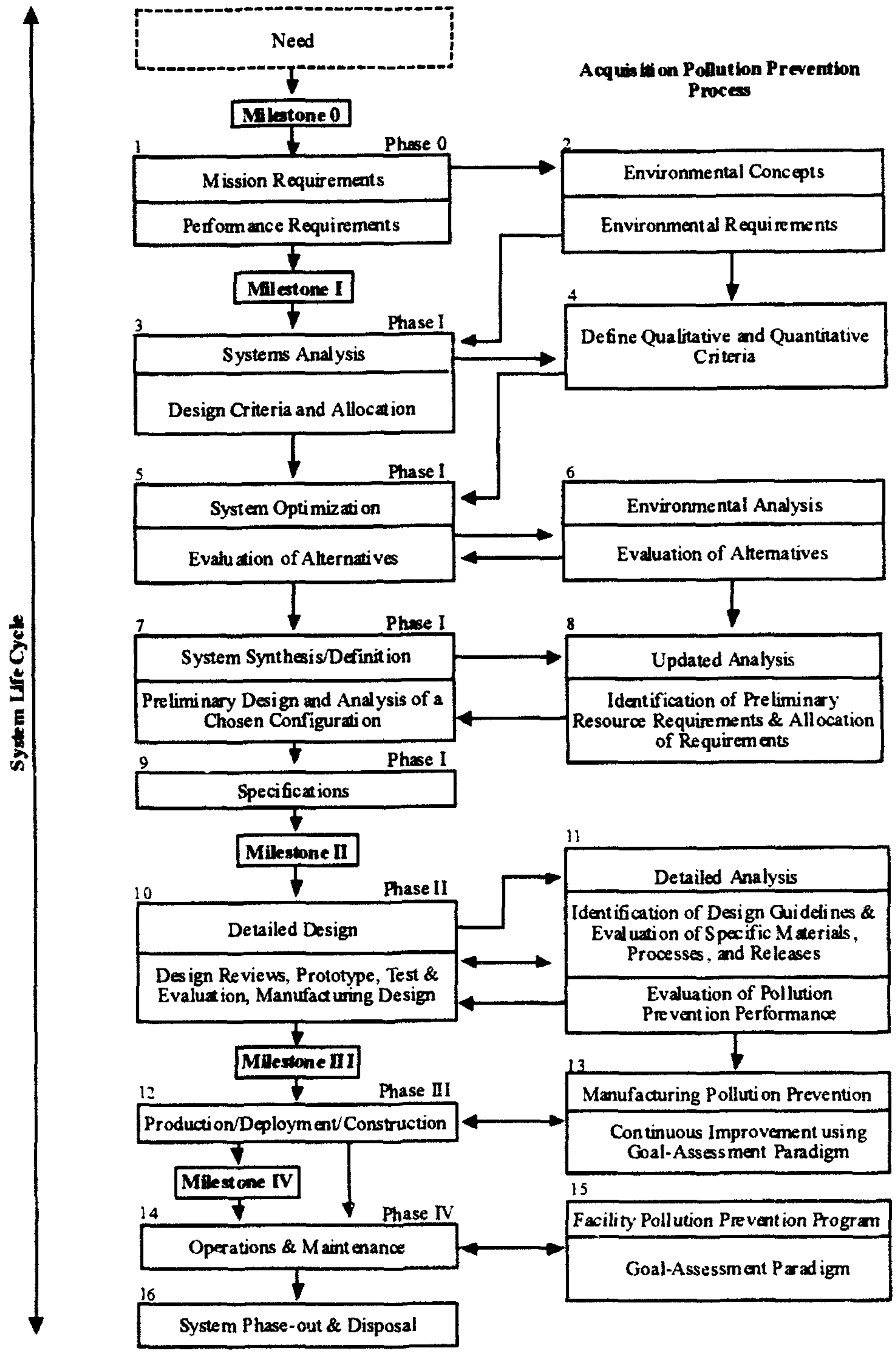

Figure 6.6. Pollution Prevention in the Systems Acquisition Process

Blocks 5 and 6. Within the boundaries established by the design criteria, alternative prime mission equipment and support configurations are evaluated through trade-off studies, and a preferred approach is selected. For each alternative, a preliminary environmental analysis is accomplished to determine the anticipated releases and impacts and the required resources associated with the alternatives. Through numerous trade-off study iterations, a chosen prime mission equipment configuration and support policy are identified.

Blocks 7, 8, and 9. The chosen prime mission equipment configuration is evaluated through a pollution prevention analysis effort which leads to the gross identification of releases and resources. The system configuration is reviewed in terms of its expected overall effectiveness and compliance with the initially specified qualitative and quantitative requirements. The ultimate output leads to the generation of sub-system specifications (and lower-level specifications) forming the basis for detail design.

Blocks 10 and 11. During the design process, direct assistance is provided to design engineering personnel in areas such as material and process selection, environmental compliance regulations, environmental costs, etc. These tasks include the interpretation of criteria; accomplishment of special studies; participation in the selection of materials, processes, equipment, and suppliers; participation in progressive formal and informal design reviews; and participation in the test and evaluation of engineering models and prototype equipment. In depth PPA is conducted based on design data.

Blocks 12 and 13. Prime mission equipment items are produced, tested, and deployed. PPA is focused on improving manufacturing process, accommodating changes in environmental compliance regulations, and inserting new technologies into the program with the potential to reduce releases and impacts or to lower life-cycle costs.

Blocks 14 and 15. The mission equipment is operated, maintained, and repaired by the customer. PPA is now a customer responsibility and is focused on reducing the releases from the customer's maintenance and repair activities.

Block 16. The system has reached the end of it useful life. The acquisition process does not include System Phase-out and Disposal so no acquisition pollution prevention activities are shown. If phase-out involves environmental impacts, disposal may be preceded by a NEPA process. A good example of this has been the deactivation and disposal of land-based missiles and their silos as a result of strategic arms treaties.

In order to reduce the level of detail used in later diagrams of the acquisition pollution prevention process, future illustrations of the process will appear as shown in Figure 6.7. This "shorthand" is defined to have the same meaning as the detailed process described in Figure 6.6.

This process for acquisition pollution prevention, along with the illustrations of the environmental impact analysis process shown in Figure 6.3 and Figure 6.4 will be used in Chapter 7 to explore the relationship between these two systems of analysis.

6.6 Acquisition Pollution Prevention Conclusions

The pollution prevention framework is useful for examining the relationships among elements of the acquisition process that interact to influence pollution prevention implementation in acquisition programs. In the programs studied, pollution prevention, environmental impact analysis, and system engineering and design are not integrated. In fact, based on the observations made, they can be assumed to be nearly unrelated. Thus, the pollution prevention framework has illustrated that pollution prevention analysis (PPA) is not fully integrated into the system acquisition process (including system engineering and design), that environmental impact analysis (EIA) as required by NEPA has not been an effective means for accomplishing PPA, and that the specific environmental requirements needed to energize the system engineering and design process have only been established for air emissions and noise impacts associated with jet engines.

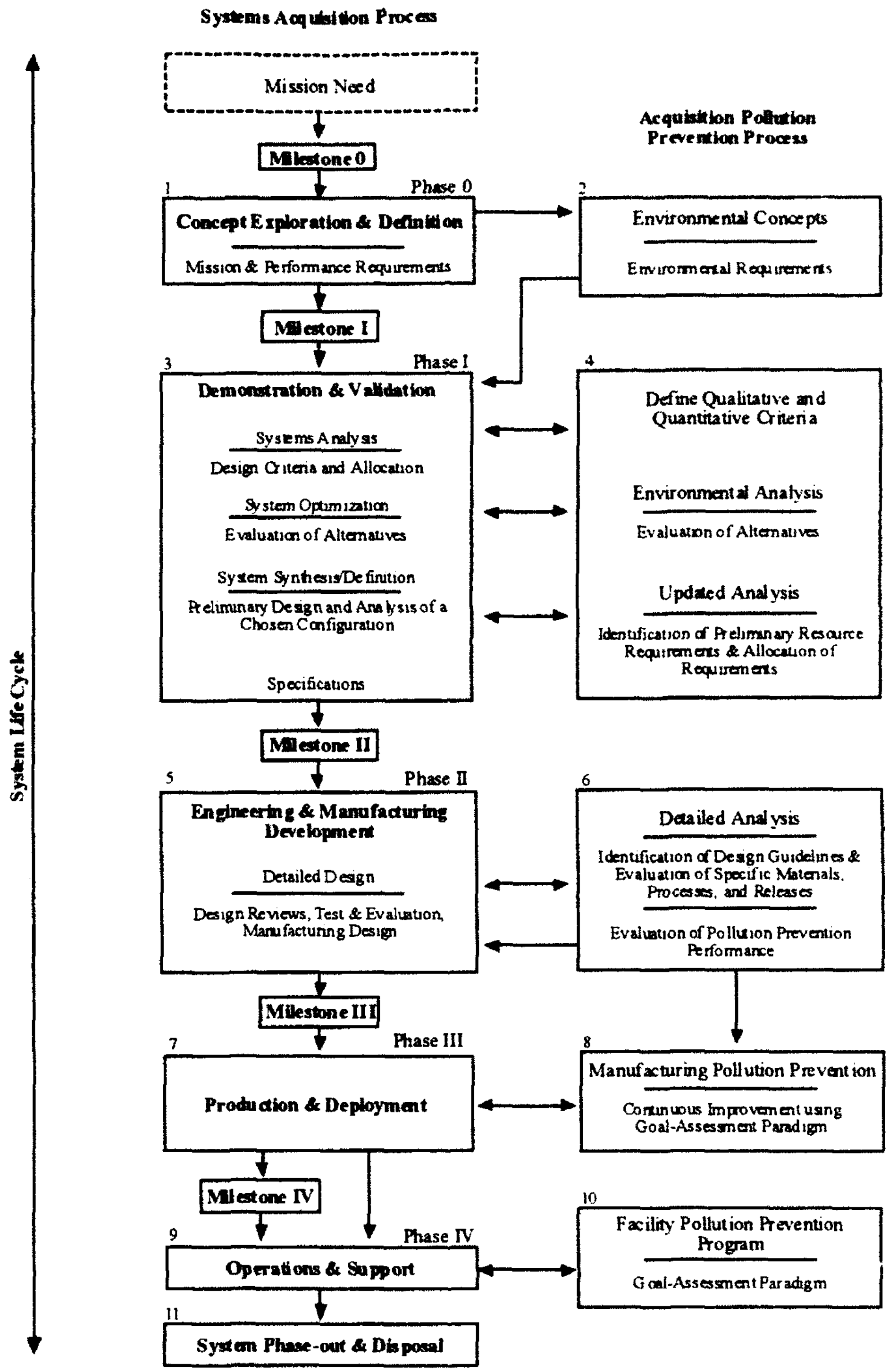

Figure 6.7. Simplified Acquisition Pollution Prevention Process

CHAPTER VII

POLLUTION PREVENTION & DOD SYSTEMS ACQUISITION POLICY

7.1 Introduction

In Chapters 5 and 6, a number of pollution prevention implementation issues were identified. Some of the issues raise questions that concern DoD policy and some do not. A summary of the implementation issues, grouped into policy areas, and categorized according to responsibility for action are shown in Table 7.1.

	Policy	Management & Technical
Government Responsibility		
Programmatic Environmental Assessment (PEA) criteria	X	
Integration of Pollution Prevention into the systems acquisition process	X	
Role of life-cycle cost analysis	X	
Hazardous materials definition	X	
Joint Responsibility		
Life-cycle cost and other analysis tools		X
Resources		X
Lessons learned and information crossfeed		X
Corporate Responsibility		
Pollution prevention policy	X	
Organizational structure		X

Table 7.1. Major Implementation Issues

In categorizing the areas by implementation responsibility, three categories of responsibility are used: 1) DoD, 2) industry, or 3) joint DoD and industry responsibility. In addition, the issues are categorized as either policy issues or management & technical

issues. Policy issues address problems in existing DoD policy. Management & technical issues can be addressed through new processes and procedures without changing current policies.

The government-responsibility policy issues will be explored in this chapter, with the exception of a hazardous materials definition which is primarily a contract and legal issue and is beyond the scope of this research. The three remaining government-responsibility policy issues associated with implementing pollution prevention in system acquisition programs are listed below:

1. There are no program review criteria for environmental issues.
2. Pollution prevention analysis has not been integrated into the systems acquisition process.
3. The requirement in DoDI 5000.2 to select hazardous materials based on life-cycle cost is not being implemented.

The current policy on these issues is contained in Department of Defense Instruction (DoDI) 5000.2, and as illustrated in the earlier chapters, its lack of clarity is causing considerable confusion within acquisition programs. Is a programmatic environmental assessment (PEA) simply an executive summary from an environmental impact analysis (EIA) document, is it a completely independent analysis, or is it something else?[1] How are environmental impact analysis (EIA) and pollution prevention activities (PPA) related? Must every hazardous materials decision be supported with a life-cycle cost estimate? These questions are each part of one of the larger issues identified above. To address these issues and to address the policy-related research question,[2] each of the government-responsibility policy issues will be analyzed.

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[1]See Chapter 6. The Navy's position is that the PEA is an independent environmental analysis which may or may not coincide with the requirement to perform environmental impact analysis under NEPA.

[2]The third research question asks, what revisions, if any, to existing pollution prevention policies, procedures, and processes are needed.

7.2 The Programmatic Environmental Assessment

The requirement for each acquisition program to prepare a Programmatic Environmental Assessment (PEA) as a part of the Integrated Program Summary is key concept for including the results of environmental impact analyses in the milestone decision process. Figure 7.1 illustrates the relationship between the PEA and the other key documents that program offices prepare prior to a milestone review.

Acquisition Milestone Documentation

Planning Documents

Acquisition Plan
Configuration Plan
Computer Resources Life Cycle Mgt Plan
Human Systems Integration Plan
Integrated Logistics Support Plan
Manufacturing Plan
Program Protection Plan
Software Development Plan
Systems Engineering Management Plan
Technology Assessment and Control Plan
Test and Evaluation Master Plan
Training Development Plan
NEPA Documents

Stand -Alone Documents

1. Test & Evaluation Master Plan
2. Program Cost Estimate
3. Independent Cost Estimate*
4. Cost & Operational Effectiveness Analysis
5. Acquisition Program Baseline*
6. Manpower Estimate Report*
7. Waivers/Reports*

Integrated Program Summary

1. Execution Status
2. Threat Highlights-Shortfalls of Existing Systems
3. Alternatives Assessed & Results
4. Most Promising Alternative & Rationale
5. Acquisition Strategy
6. Cost Drivers & Major Trade-Offs
7. Risk Assessments & Plans to Reduce Risk
8. Affordability of Selected Alternative
9. Recommendations

Annexes

A. Program Structure
B. Program Life-Cycle Cost Estimate Summary
C. Acquisition Strategy Report*
D. Risk Assessment
E. Programmatic Environmental Assessment*
F. Affordability Assessment
G. Cooperative Opportunities Document*

* Statutorily Imposed Requirement

Figure 7.1. Programmatic Environmental Assessment

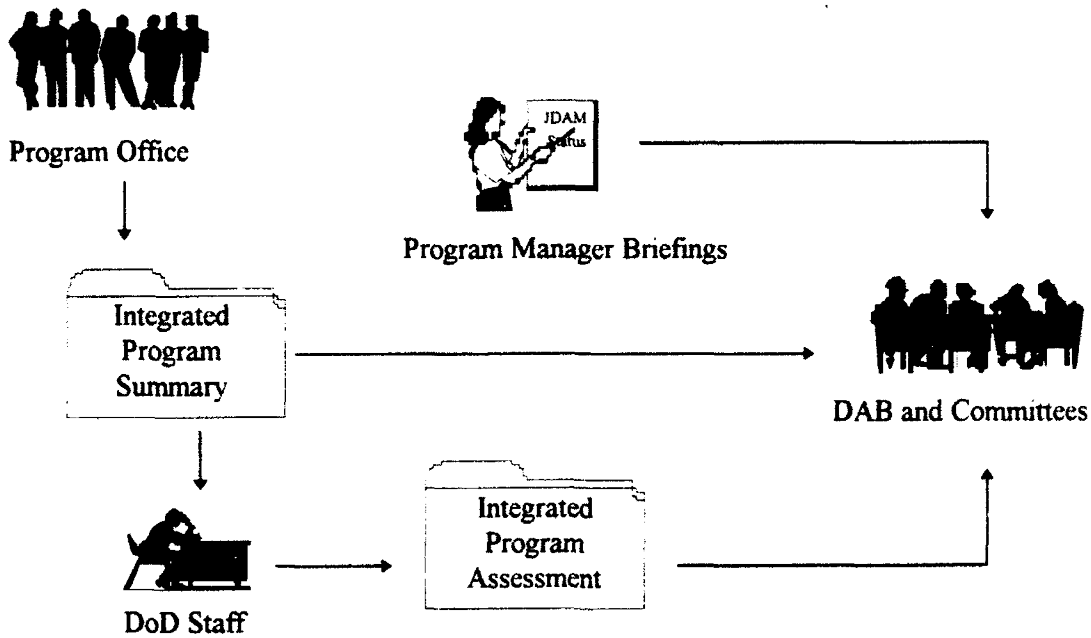

Figure 7.2. Acquisition Program Review Process

Once the Integrated Program Summary is completed by the program office, it is forwarded to Washington D.C. and it is reviewed by the DoD staff prior to the meeting of the Defense Acquisition Board, the milestone decision authority. As shown in Figure 7.2., the DoD staff evaluates program's Integrated Program Summary and the staff's analysis and comments are assembled into a Integrated Program Assessment. Both documents, the Integrated Program Summary and the Integrated Program Assessment, are then provided to the members of the Defense Acquisition Board before the board meets to consider the program.

Thus, information on the program's environmental impacts is summarized in a programmatic environmental assessment (PEA) and the PEA reaches the decision makers as Annex E, to the Integrated Program Summary.

The programmatic environmental assessment (PEA), as described in DoDI 5000.2, is intended to be an environmental impact analysis (EIA) summary document. Based on the PEA format given in DoDM 5000.2-M, which is a standard environmental impact

statement (EIS) format, the authors' of these two DoD regulations appear to be describing a programmatic environmental impact statement (PEIS).[3] Why the authors' chose to create the new term, programmatic environmental assessment, without defining it is unknown. Perhaps the term was used in recognition of the fact that National Environmental Policy Act (NEPA) requirements can often be satisfied by preparing a shorter environmental assessment (EA) instead of a full environmental impact statement (EIS). Thus, calling the document a programmatic environmental assessment (PEA) left open both choices.

The need for programmatic environmental impact statements (PEISs) has been the subject of several Supreme Court cases. The only case to provide in-depth consideration of the PEIS issue is Kleppe v. Sierra Club,[4] but the opinion left the details of scope and timing of analysis unresolved.[5] The CEQ regulations apply to an EIS of any scope, whether programmatic or individual project in scope. Thus, there are no specific guidelines for the PEIS *per se*.[6]

A key reason why past programmatic environmental assessments (PEAs) have not been effective decision making tools is that there are no DoD criteria for either writing or evaluating the PEA. No one in the acquisition process understands what is expected in a PEA, how to evaluate a PEA, or how to use a PEA. Given the broad, but undefined, scope of the PEA, many of the deficiencies in the current acquisition process that were identified in this research can be corrected by providing a clear set of criteria for the PEA.

Given the fact that the analysis required by a PEA is unclear at best, the term will be defined here to include both macro and micro-focused environmental analysis. The critical

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[3]The PEIS terminology is used in the EIA literature.

[4]Kleppe v. Sierra Club, 427 US 390 (1976).

[5]Lorene L. Sigal and J. Warren Webb, "The Programmatic Environmental Impact Statement: Its Purpose and Use," The Environmental Professional, v. 11, 16.

[6]Ibid.

part of this definition is that the PEA[7] addresses both macro-focus, environmental impact analysis (EIA) and micro-focused, pollution prevention analysis (PPA) as described in Chapters 5 and 6. Conceptually, the PEA is being used in the acquisition regulations to integrate all environmental analyses into a single, objective, executive-level summary document to support decision making. The criteria recommended below help define the PEA's scope without altering this overall purpose.

In Chapters 5 and 6, eight major areas of PEA criteria were identified. Each area is listed below together with the specific research topic where the need for the criterion was discussed:

	Criteria	Research Topic
1.	Integration of EIA and PPA	EIA in acquisition programs
2.	Environmental impact analysis	NEPA standards of analysis
3.	Public input and comment	NEPA standards of analysis
4.	Environmental values	Design-materials paradigm
5.	Environmental compliance regulations	Compliance paradigm
6.	Pollution prevention requirements	Design-materials paradigm
7.	Pollution prevention goals	Waste-reduction paradigm
8.	New technologies	Design-materials paradigm
9.	Monitoring	Waste-reduction paradigm

Similar lists of criteria, or considerations, for other functional areas are already included in DoDI 5000.2. For example, Attachment 1 to Part 6, Section C lists typical reliability and maintainability issues to be considered at milestone decision points and during the acquisition phases leading up to the milestones. A similar list for survivability considerations is included in Part 6, Section F and a list of production readiness considerations is included in Part 6, Section O. Based on these and other examples in DoDI 5000.2, there is ample precedent for listing considerations to be included in the acquisition process.

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[7]If using the term, programmatic environmental assessment (PEA) in this way is confusing, another term can be selected.

Based on this precedent of including two to three page lists of considerations in DoDI 5000.2, recommendations for addressing each of the nine areas will be presented.

7.2.1 Integration of Environmental Impact Analysis and Pollution Prevention Analysis

First, DoDI 5000.2 should clearly state that the programmatic environmental assessment (PEA) is a summary document which brings together all environmental analyses conducted on the program. This includes environmental impact analysis (EIA) that is required by the National Environmental Policy Act (NEPA) as well as all other environmental analyses. This would correct the problem, identified in Section 6.4.1, that the programmatic environmental assessment (PEA) is currently being used to summarize only the results of the EIA process, which as currently implemented, does not usually address the program's pollution prevention activities.

This new criterion for the programmatic environmental assessment (PEA) would establish the PEA as a "supra-NEPA" document that fulfills DoD's legal obligation to consider environmental impacts in decision making as well as efforts to reduce non-location specific potential impacts and environmental risks through pollution prevention analysis (PPA), where PPA is defined to mean all micro-focused environmental analysis. The PEA would include both quantitative and qualitative data and information.

7.2.2 Environmental Impact Analysis

The second criterion follows directly from the first--the programmatic environmental assessment (PEA) summarizes and transmits the results of environmental impact analysis (EIA) conducted under the National Environmental Policy Act (NEPA). This criterion is needed to eliminate the problem identified in Section 6.4.3.1, in which the Navy argued that the requirements of DoDI 5000.2 could be satisfied by an environmental impact analysis (EIA) that was not subject to the procedural requirements of NEPA. To implement this criterion, the following specific requirements should be included in DoDI 5000.2.

If an environmental impact statement (EIS) is filed, the PEA should include the information usually contained in an EIS's executive summary along with a copy of the record of decision (ROD). The information in the executive summary normally includes a brief description of the proposed action, alternatives, potential impacts, and potential mitigation actions. If an environmental assessment (EA) is conducted which lead to a finding of no significant impact (FONSI), the same executive summary information from the EA should be included along with a copy of the FONSI. If the service or defense agency uses a categorical exclusion (CATEX), a copy of the signed CATEX document should be included.

Implementing these requirements insures that NEPA requirements have been met and provides a summary of the results of the environmental impact analysis to decision makers.

7.2.3 Public Comment

The public comment criterion would require a statement in the programmatic environmental assessment describing what if any public input was sought during the environmental impact analysis process and in the pollution prevention analysis process, the nature of the input, and how it was used. This criterion is needed to address the problem identified in Section 6.4.3.4 that the acquisition decision process does not include public involvement. This statement in the PEA would inform the members of the Defense Acquisition Board about the nature, scope, and impact of any public involvement in the program's environmental analyses.

7.2.4 Environmental Values and Risks

This criterion involves clearly stating the government's environmental values that are associated with major program activities; for example, selecting hazardous materials, setting aircraft noise requirements, handling radioactive materials, etc. The values should

be expressed in terms of indicators that, either quantitatively or qualitatively, identify the important environmental issues and risks.

The need for an evaluation of environmental values was identified in reviewing Lockheed Aeronautical Systems Company's implementation of the design-materials paradigm in Section 5.3.4.1. In evaluating whether or not to use a hazardous material, the company qualitatively evaluates seventeen factors that relate to the material's potential environmental, health, and safety performance. The procedure is useful in helping managers make decisions, but the government had no input into the process of determining what factors, or values, are important. By failing to provide this information for the evaluation process, the government allows its contractor's to decide what is important in selecting hazardous materials.

Including this criterion in the programmatic environmental assessment will insure that important environmental values have been identified and can be used to guide the numerous decision processes that are part of a development program.

7.2.5 Environmental Regulations

The purpose of this criterion is to fundamentally change the paradigm for reviewing the impact of environmental compliance regulations on a program. Under this criterion, programs would list new environmental compliance requirements, both federal and state, and explain their impact.

The requirement to update the analysis of environmental compliance regulations is similar to updating the program's threat assessment. Both are dynamic variables that continually change over the development cycle of the system. Thus, the regular updates to this analysis are needed to ensure that the changes to the set of environmental compliance variables, which are external to the program and beyond the program manager's control, are addressed as the program develops.

At phase 0, the initial environmental assessment would assess the program's compliance challenges. The compliance challenges could be defined in terms of the most costly to achieve, the most technically difficult to achieve, or be based on other factors. Subsequent programmatic environmental assessments (PEAs) would update the initial analysis and specifically address the impact of new compliance requirements on the program.

The need for this criterion is based on the finding that in none of the eleven programs studied were designers aware of state environmental requirements. In addition, the impact of new regulations on the user, were not routinely evaluated. The benefits of regularly evaluating environmental compliance requirements were illustrated in McDonnell Douglas Aerospace - East's (MDA-E) strategic-planning process.

7.2.6 Pollution Prevention Requirements

Key program environmental requirements should be specifically stated and linked to environmental values, risks, or compliance requirements. The requirements should be realistically achievable and should be translated into specified values in contracts. Items that require test and evaluation should be included in the Test and Evaluation Master Plan. Facility and equipment requirements needed to achieve environmental requirements should be tracked through the Integrated Logistics Support Plan.

Most of the programs studied had no system environmental requirements included in program contract documents. The exception to this, were jet engine contracts which include requirements for jet engine noise testing and air emission requirements. Several impacts from not including environmental requirements in program contracts were observed. First, system designers and managers were not aware of the user's compliance requirements. Second, system engineering management tools could not be used to track requirements, responsibilities, or costs. This results in the late identification of requirements and increases program costs.

7.2.7 Pollution Prevention Goals

Pollution prevention goals, or "soft" requirements, should also be explicitly stated. This criterion is needed to ensure DoD and Air Force environmental goals are being implemented. The Air Force's efforts to reduce the use of the seventeen chemicals targeted in the EPA 33/50 Program is an example of an environmental goal. In addition to general national goals such as the 33/50 Program, goals may also address specific environmental risks or compliance issues.

7.2.8 New Technologies

This criterion addresses the environmental aspects of new technologies being considered for the program. The programmatic environmental assessment (PEA) should address new and emerging technologies being considered for use on the system. In addition, the PEA should also address new technologies that are being specifically considered or that are needed to meet the program's environmental requirements and goals. This section would address the potential environmental impacts and risks (in comparison with established technologies) associated with manufacturing, operational use, maintenance and repair, and disposal of new materials, processes, electronic devices, etc. In addition, potential environmental compliance issues associated with each technology should be identified and requirements for additional data on environmental issues should be included. The analysis should be updated in subsequent PEAs.

The benefit of looking forward at environmental processes and technologies, before specific hazardous materials are proposed for use in a program was illustrated at Lockheed on the F-22 program. Many problems can be avoided by providing design guidance to the engineers early in the design process.

7.2.9 Monitoring

The monitoring criterion recognizes the need to determine how well the requirements and goals are being met and to determine the actual impacts that result from

earlier program decisions. This criterion closes the management loop by providing feedback to decisionmakers. Specifically, the PEA should identify what requirements, goals, and outcomes will be tracked and it should include the appropriate metrics for displaying the program's current environmental status.

7.2.10 Programmatic Environmental Assessment Conclusions

By added the nine criteria just described to the general requirement to prepare a programmatic environmental assessment (PEA), future PEAs will not only contain information covered in a program's environmental impact analysis, but they will also include information on the program's broader environmental management efforts. By addressing both environmental impact analysis (EIA) and pollution prevention analysis (PPA), a more complete and integrated picture of a program's environmental status will be provided. Finally, the resulting PEAs should allow senior managers to focus on the important environmental issues at each milestone and should provide an environmental management framework foı managers at all levels of program management.

7.3 Structuring Pollution Prevention Analysis

This policy topic concerns how pollution prevention can be integrated into the systems acquisition process. Some of the issues surrounding this topic surfaced during the discussion of the PEA. Specifically, the need to integrate the results of EIA and PPA. While the PEA criteria recommend integration of the results of EIA and PPA, this policy topic explores the integration of the underlying processes.

7.3.1 Defining the Problem

Environmental impact analysis (EIA), as required by NEPA has not been an effective means for accomplishing pollution prevention in systems acquisition programs. To correct this problem, a broader system of environmental planning could be instituted that includes environmental impact analysis and pollution prevention analysis (PPA).

In Section 6.4.4, three limitations of the environmental impact analysis (EIA) process as it is used in systems acquisition were identified: 1) EIA is too focused on site-specific impacts, 2) EIA is not continuous, and 3) EIA is an add-on process. The addition of a system of pollution prevention analysis would address the first limitation, but it also complicates analysis of the final two limitations since both EIA and PPA must be considered in an evaluation.

Given these findings, structuring an approach to environmental analysis in the systems acquisition process involves two sets of issues: 1) how should environmental impact analysis and pollution prevention analysis be structured in relationship to the acquisition process in order to overcome the current limitations in EIA implementation, and 2) the procedures and level of detail that should be put into the policy to achieve the desired results.

7.3.2 Specify Values

The Air Force's pollution prevention values were identified in a series or four, one-hour interviews with Mr. Gary D. Vest,[8] the Deputy Assistant Secretary of the Air Force, Environment, Safety, and Occupation Health.[9] The interviews took place in Mr. Vest's office in the Pentagon between March and May 1992.

The interview process is described in Appendix A. At the end of the process, six values were identified. The values, shown in Table 7.2, are unordered in the sense that none of the values is always more or less important than the other values. The six values will be used to select a preferred alternative following an evaluation that addresses all of the alternatives on each of seven criterion. The source for the criteria is described next.

[8]Since the interviews took place, Mr. Vest accepted a position on the DoD staff and is now serving as the Deputy to the Deputy Under Secretary of Defense for Environmental Security.

[9]This is the senior environmental position in the Air Force.

Number	Values
1.	Support the mission
2.	Comply with law and policy
3.	Do the right thing - Minimize environmental releases and impacts - Reduce the use of and worker exposure to hazardous and toxic chemicals - Give priority to preventing problems
4.	Make good business decisions - Cost is key, but use a life-cycle time perspective for long term acquisition decisions - Prevent future cleanup liabilities
5.	Provide strong leadership and effective management
6.	Act responsibly and openly with local communities and the public

Table 7.2. Air Force Pollution Prevention Values

Six of the seven criteria that will be used in the evaluation process are based on the requirements for a system of analysis that ensures organizational learning over time that was proposed Taylor.[10] The final criterion involves the number of environmental specialists needed. This criterion was adopted based on the analysis in Section 6.4.4 that shows that EIA has never been integrated into the acquisition process.

7.3.3 Alternatives

Of the two aspects of the problem identified earlier, the relationship between pollution prevention analysis (PPA) and environmental impact analysis (EIA) is the more fundamental issue. Creating a set of procedures to implement PPA is dependent on first deciding the nature of the relationship between PPA and EIA since the procedures will differ depending on how the more fundamental issue is decided.

Based on this logic, Figure 7.3 shows a decision tree with four alternatives. The top branch makes no change to how NEPA is currently implemented in DoD. Alternative 1 is the no action alternative where the current policy is left in place and no new policy on pollution prevention is added. Alternative 2 constructs a set of procedures for

[10]Taylor's standards of analysis are a part of the pollution prevention framework. The standards are used as criteria in evaluating current acquisition programs in Section 6.4.3.

implementing pollution prevention analysis (PPA) as a separate and independent system of analysis, but does not change environmental impact analysis (EIA) implementation. The bottom branch changes current NEPA implementation to consider pollution prevention. On this branch, two main alternatives are considered: in Alternative 3, distinct but closely related and integrated systems of EIA and PPA are established; and in Alternative 4, PPA is fully incorporated into EIA.

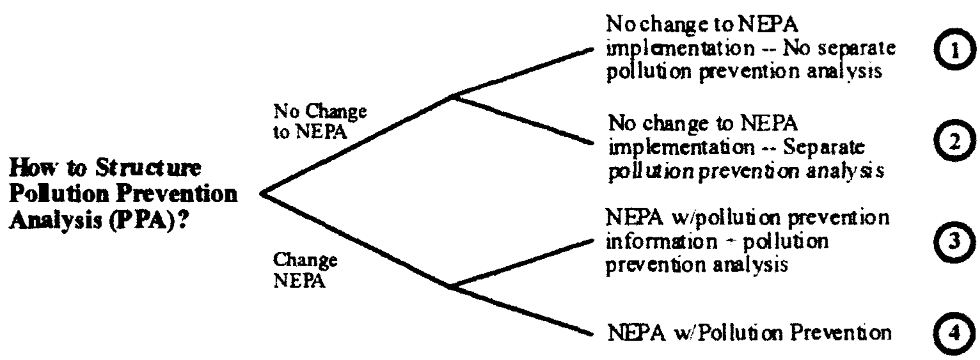

Figure 7.3. Pollution Prevention Analysis Alternatives

While Figure 7.3 illustrates the key differences among the four alternatives, it does not adequately define the alternatives for analysis, so each alternative will first be defined in additional detail.

7.3.3.1 <u>Alternative 1 - No Action</u>

Alternative 1, the no action alternative, leaves the current policy in place. Under this alternative, pollution prevention analysis would not be required by DoD policy and environmental impact analysis would be carried out using the existing guidance. Any changes to the structure of environmental analysis would be left to the services or to individual program managers.

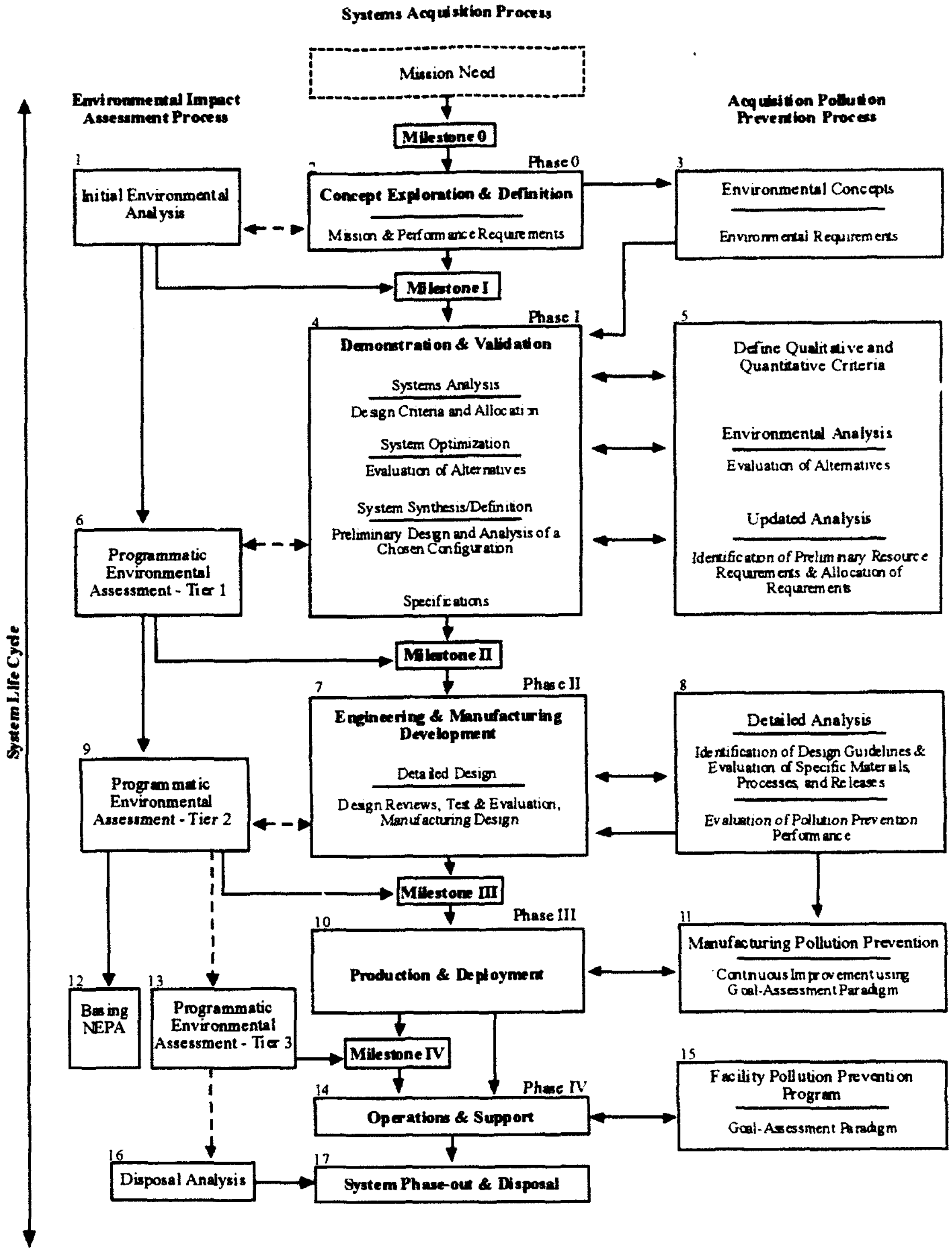

Figure 7.4. Separate Environmental Impact and Pollution Prevention Processes (Alternative 2)

7.3.3.2 Alternative 2 - Separate Systems of Analysis

Alternative 2 is characterized by maintaining EIA as a separate and independent system of analysis. This alternative is graphically shown in Figure 7.4.

The EIA process is shown on the left side of the figure, the acquisition process is shown in the center, and a PPA process is shown on the right. The EIA portion of the figure is taken directly from the observed EIA process shown in Figure 6.3. The PPA portion of the figure is taken from the PPA process that was developed in Chapter 6 and is shown in Figure 6.7. Table 7.3 lists the seven criteria and briefly describes Alternative 2's characteristics for each criterion.

Criteria	Characteristics of EIA and PPA
Focus on Important Issues	EIA will continue to focus on the biogeophysical impacts associated with system testing and with selecting bases for system beddown while PPA focuses on releases, hazardous material use, source reduction, less costly methods of compliance, etc.
Alternatives Studied	EIA studies alternative systems and basing options. PPA examines alternative materials, processes, conservation methods, procedures, etc.
Public Participation	Maintains the macro focus of EIA, minimizing the information content in NEPA documents. This reduces potential criticism of program management and may reduce public interest. Eliminates a potential source of peer review of PPA. Reduces potential public "buy-in" of program PPA goals and minimizes public input on PPA.
Legal Review	Minimizing the amount of information included in NEPA documents producing less complex documents. This should help reduce the potential for successful legal reviews that delay programs. If future court decisions adopt pollution prevention as part of EIA, successful challenges could increase. Minimizes internal legal review of PPA actions.
Incentives to Use Analysis	EIA is an add-on process that is only conducted immediately prior to milestone decision points. It fulfills a requirement in the review process. Little incentive to use results of EIA. Information from EIA and PPA will be integrated before the milestone review to write the PEA. Little or no time to gather additional information if integration uncovered the need for additional information. Fosters small environmental staffs, organized as a core function that advise program offices and oversee contract NEPA efforts. PPA is assigned as a additional duty within the program office.
Continued Improvement	As an add-on process, NEPA documents are not used for decision making, resulting in little incentive for improvement. PPA results should be monitored continuously. Program manager feedback provides strong incentive for improvement.
Number of Environmental Specialists	Allows minimum number of Government employees. Both EIA and PPA can be contracted.

Table 7.3. Characteristics of Separate Systems of Analysis (Alternative 2)

Alternative 2, separate systems of analysis, implements pollution prevention with the least disruption to the existing acquisition process and maintains NEPA-based EIA as an independent system of analysis. Environmental requirements and criteria for the acquisition programs are developed using a system of PPA. In this alternative, NEPA maintains its macro focus and PPA fulfills the need for analysis with a micro focus and little or no effort to coordinate the analyses occurs.

From a program management point of view, this option minimizes the potential for program delay through potential NEPA legal actions, where the goal of the EIA process is procedural compliance with NEPA. The role of EIA as a planning tool is minimized since EIA is conducted as an intermittent add-on process to the acquisition process.

The effectiveness of PPA may also be reduced since PPA lacks a macro focus. EIA works to present the "big picture" which provide context and insight for establishing program requirements and goals. In addition, if PPA information is not included in NEPA documents, there is no avenue for external peer review or public comment on PPA efforts.[11]

Finally, maintaining separate systems EIA and PPA may minimize the number of government environmental specialists needed to implement environmental analysis. This may occur because EIA will continue to be accomplished by contract with a small number of environmental specialists while PPA can be contracted to the prime system developer and managed as an additional duty within the program office. This can be see as a positive outcome at a time of declining defense budgets and manpower. On the other hand, it also allows the acquisition process to avoid integrating environmental specialists into the acquisition process, thus minimizing the effectiveness of both EIA and PPA.

[11]External--refers to external to DoD.

7.3.3.3 Alternative 3 - Integrated Systems of Analysis

In Alternative 3, EIA and PPA are maintained as separate systems of analysis that are integrated where possible. The characteristics of the alternative are summarized in Table 7.4. This is the most flexible of the three alternatives and is shown in Figure 7.5. This alternative takes the traditional approach to environmental management--Setting up separate, but hopefully coordinated, parallel programs.

Criteria	Characteristics of EIA and PPA
Focus on Important Issues	Macro and micro analysis are integrated into a system that addresses biogeophysical impacts associated with testing and basing as well as design issues concerning releases, hazardous material use, source reduction, less costly methods of compliance, etc.
Alternatives Studied	EIA focuses on alternative systems and basing options, but also includes details on the mitigation potential of alternative materials, processes, conservation methods, procedures, etc.
Public Participation	Increases the information content in NEPA documents. This increases potential criticism of program management and may increase public interest. Provides a limited source of peer review of PPA. May allow public "buy-in" of program PPA goals and may provide a forum for public input on PPA.
Legal Review	Increasing the amount of information included in NEPA documents, produces more complex documents that may increase the potential for successful legal reviews that delay programs. If future court decisions adopt pollution prevention as part of EIA, successful challenges will not increase. Increases the need for internal legal review of PPA actions.
Incentives to Use Analysis	EIA is an integrated part of the acquisition process increasing the level of access environmental specialists have to program planning and decision making. Information needed for the PEA is integrated as needed. Fosters the placement of environmental specialists in program offices to handle day-to-day management activities. A core environmental staff, is still required to provide depth of expertise in different disciplines.
Continued Improvement	NEPA documents present a comprehensive picture of program impacts and status. Environmental management activities are separated into their traditional EIA and PPA functions. EIA and PPA receive regular feedback providing a strong incentive for improvement.
Number of Environmental Specialists	Increases the number of government employees needed, but not as much a single system of analysis. Makes contract support easier to obtain since EIA and PPA maintain distinct identities. Requires an on-going EIA "presence" and focus that is not required for separate systems of analysis.

Table 7.4. Characteristics of Integrated Systems of Analysis (Alternative 3)

Keeping the efforts separate ensures that the required expertise is available to execute each program. It may also allow EIA to continue to be supported by a small

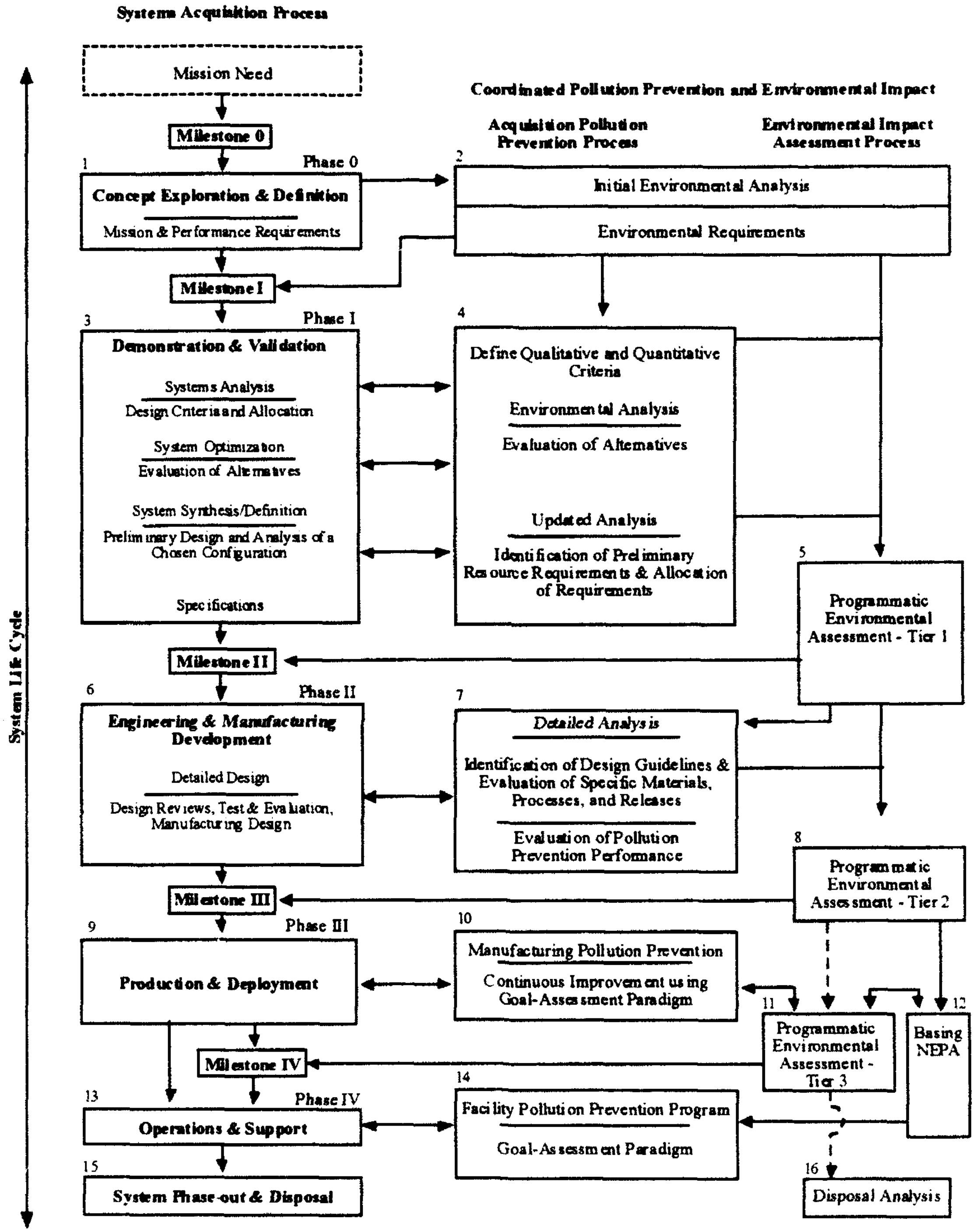

Figure 7.5. Integrated Environmental Impact and Pollution Prevention Processes (Alternative 3)

number of environmental specialists assigned to a core environmental support office. If this occurs, the effectiveness of EIA as a planning methodology will not be realized since responsibility for EIA would continue to be separated from program planning and management.

7.3.3.4 Alternative 4 - A Single System of Analysis

Under Alternative 4, a single system of environmental analysis is created that combines EIA and PPA. Alternative 4 is graphically illustrated in Figure 7.6 where the acquisition process is shown on the left size of the figure and an integrated environmental analysis process that includes both EIA and PPA is shown on the right.

This alternative provides a holistic approach to environmental management and planning and encourages the placement of environmental specialists in the program offices. NEPA documents serve more as summaries of on-going planning and management activities instead of as one time evaluations of environmental impacts. Traditional PPA activities are opened to public comment through NEPA procedural requirements. With greater staffing levels, more environmental analysis can be accomplished in-house. Classified programs, where NEPA documents are not publicly reviewed, benefit from a stronger environmental staff and the increased level of experience among government environmental specialists.

Full integration also increases the amount of information available to program opponents outside the DoD and may increases the level of external scrutiny that acquisition programs face. This could result in tougher environmental requirements and goals, increasing program cost. In addition, as NEPA documents become more complex, the probability of successful legal challenges that delay the program may also increase.

The characteristics of a single integrated system of EIA and PPA are shown in Table 7.5.

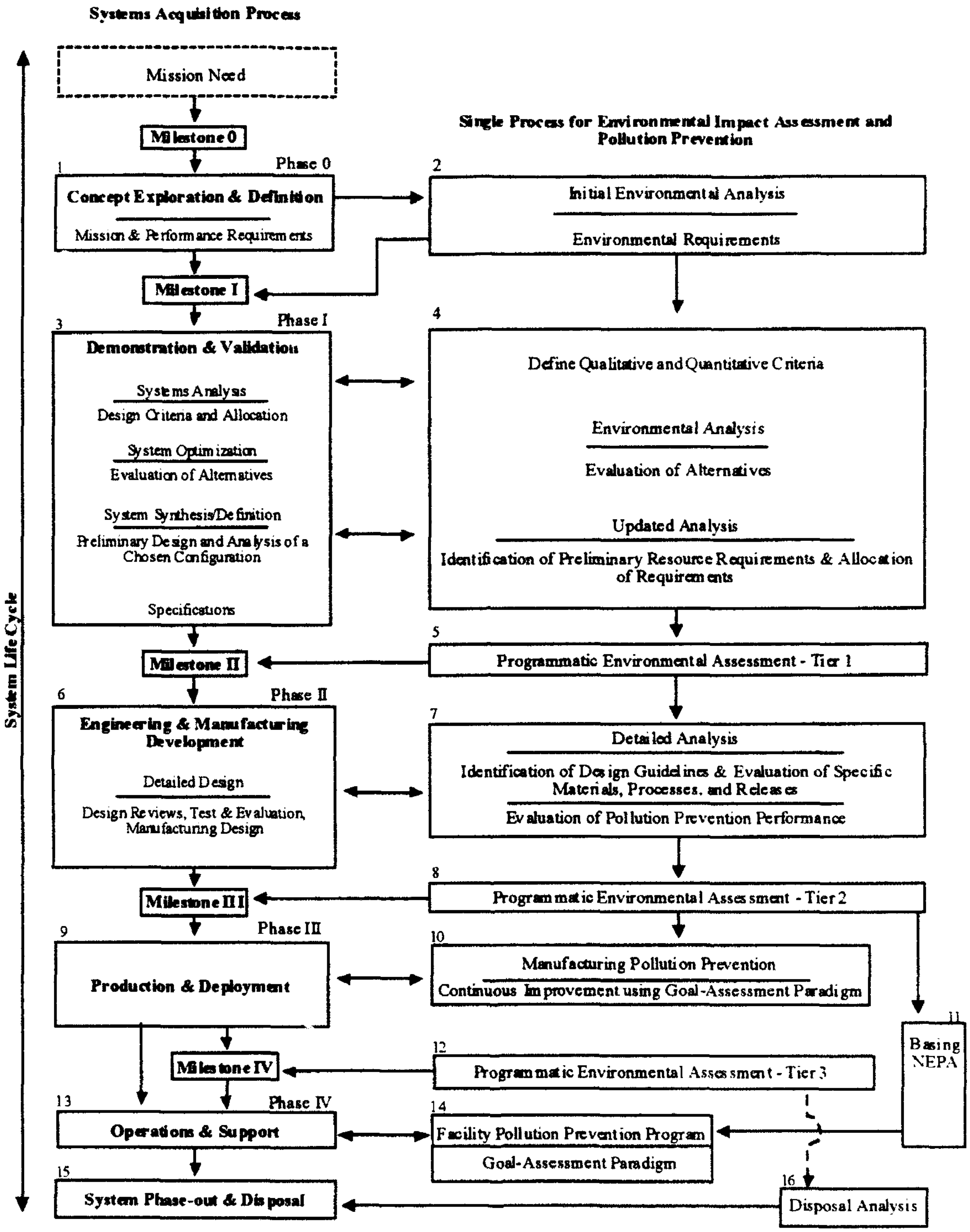

Figure 7.6. A Single Environmental Analysis System (Alternative 4)

Criteria	Characteristics of EIA and PPA
Focus on Important Issues	Macro and micro analysis are integrated into a system that addresses biogeophysical impacts associated with testing and basing as well as design issues concerning releases, hazardous material use, source reduction, less costly methods of compliance, etc.
Alternatives Studied	EIA focuses on alternative systems and basing options, but also includes details on the mitigation potential of alternative materials, processes, conservation methods, procedures, etc.
Public Participation	Maximizes the information content in NEPA documents. This increases potential criticism of program management and may increase public interest. Provides a source of peer review of PPA. Allows public "buy-in" of program PPA goals and provides a forum for public input on PPA.
Legal Review	Increasing the amount of information included in NEPA documents produces more complex documents that may increase the potential for successful legal reviews that delay programs. If future court decisions adopt pollution prevention as part of EIA, successful challenges will not increase. Increases the need for internal legal review of PPA actions.
Incentives to Use Analysis	EIA is a fully integrated part of the acquisition process increasing the level of access environmental specialists have to program planning and decision making. Information needed for the PEA is integrated on a daily basis.
Continued Improvement	NEPA documents present a comprehensive picture of program impacts and status. Environmental management activities are not artificially categorized and compartmentalized as NEPA and non-NEPA. EIA and PPA receive regular feedback providing a strong incentive for improvement. Fosters the placement of environmental specialists in program offices to handle day-to-day management activities. A core environmental staff, is still required to provide depth of expertise in different disciplines.
Number of Environmental Specialists	Increases the number of government employees needed. Full integration requires an environmental manager in the program office.

Table 7.5. Characteristics of a Single System on Analysis (Alternative 4)

7.3.4 Evaluate Alternatives

The alternatives will be evaluated by comparing the characteristics of the alternatives for each criterion with the Air Force's pollution prevention values. Each alternative will then be scored as shown in Table 7.6.

Symbol	Meaning
-	Alternative is undesirable on the characteristic
	Alternative is neither preferred nor undesirable
+	Alternative is preferred on the characteristic

Table 7.6. Scoring System

This procedure will result in seven sets of comparisons, one for each criterion. Following this process, the results of the evaluation are summarized in Table 7.7.

7.3.4.1 Focus on Important Issues

Environmental impact analysis (EIA) is a well developed planning tool for development projects that has not been adequately adapted to systems acquisition. EIA has been used in the acquisition process primarily as a tool for assessing the biogeophysical impacts associated with installation land use and development projects that are undertaken at military installations as part of the beddown process. The beddown process consists of selecting a base where the system will be located and planning and implementing the changes to facilities, equipment, and staffing that are needed to operate the new system. Planning for system beddown usually begins near the mid-point of acquisition phase II, engineering and manufacturing development. Given this development focus in acquisition EIA, relevant issues for decision making at milestones 0, I, or II have only infrequently been identified in the past.[12]

Alternative 2 improves this situation by adding an independent PPA process that focuses on micro-level issues such as releases to the environment, hazardous material uses, opportunities for source reduction, finding less costly methods of compliance, etc. Alternatives 3 and 4 also identify these micro-level issues, but offer the opportunity to start linking environmental indicators to predicted impacts early in the acquisition process. Because of this integration, Alternatives 3 and 4 have the potential to identify harmful releases and impacts sooner in the acquisition process. Based on the Air Force's value of "doing the right thing" by minimizing releases and impacts and for "giving priority to preventing problems," Alternatives 3 and 4 are preferred over Alternative 2. Alternative 1 is undesirable on this criterion since micro-level issues may not be addressed.

[12]This conclusion is borne out by the NEPA documents that were reviewed in Chapter 6.

Under Alternatives 2 and 3, parallel systems of EIA and PPA are maintained. Having two systems of analysis may improve the potential to identify important issues since EIA and PPA may be accomplished in different government offices. In addition, EIA and PPA technical support would most likely be provided by different contractors. Employing an environmental planning contractor for EIA and the system contractor for PPA would increase the extent and depth of independent analysis and would provide different sources of input to the government. This would tend to favor these alternatives in being able to focus on important issues. On the other hand, having two systems of analysis tends to reduce the depth of analysis that can be carried out in either system because of limits on the total resources that are available. Under Alternative 4, more of the environmental planning would be done in-house or a single contractor would be responsible for EIA and PPA. This could enhance understanding of both macro and micro impacts and lead to better planning and design.

As a result, the no action alternative is the least desirable. Among the three remaining alternatives, none is clearly preferred over the others based on the criterion of focusing on important issues, but all three are much preferred over Alternative 1.

7.3.4.2 Alternatives Studied

EIA alternatives usually focus on macro-level alternatives. During the early phases of the acquisition process, the EIA alternatives should parallel those being used in the program's Cost and Operational Effectiveness Analysis (COEA). At the same time, differences in micro-level alternatives may impact the life-cycle cost portion of the COEA. If micro-level considerations are important, additional macro-level alternatives may be needed to compare among alternatives for meeting the mission need. Thus, it is important that early environmental analysis look at both macro and micro-level alternatives.

In addition, early evaluation of new mission-related system technologies as well as new environmental technologies will allow the systems engineering process to trade among the broadest set of parameters as it narrows in on a preferred design.

At later stages of the development process, the alternatives involve micro-level design alternatives for the system and alternative beddown locations.

Based on the Air Force's value of "making good business decisions," Alternatives 2, 3 and 4 are preferred over Alternative 1 for this criterion since a system of PPA enhances the consideration of alternatives throughout the development process. It is difficult to project whether one of the preferred alternatives would be better over the entire acquisition process for enhancing the consideration of alternatives; however, during the early stages of the acquisition process, Alternatives 3 and 4 are preferred since this stage of the process involves the most government planning and Alternatives 3 and 4 require more government employees. The assumption is that a greater number of government environmental specialist will be able to exert a greater influence on the planning process. Based on this logic, Alternatives 3 and 4 are the most preferred and Alternative 1 is undesirable.

7.3.4.3 Public Participation

Public participation is seen within the DoD as both a positive and a negative factor. Within the acquisition community, the public participation aspects of EIA are frequently seen as a liability. In looking at public involvement in the EIA process, the DoD Inspector General found that,

> The Military Departments did not make a public disclosure of environmental documents during or after the assessment of environmental consequences. Consequently, the decisionmakers, environmental agencies, and the public were not given the opportunity to adequately consider environmental consequences of these programs.
>
> Army. The M1A2 Tank Program Office personnel assumed that the EA and other environmental documents were the property of the Department of the Army and were not released. . .

Navy. The Navy indicated that the preparation of environmental documents for its weapon systems acquisition program decisions was not required. Consequently, Navy did not involve the public in any decision made on its acquisition programs.

Air Force. According to officials at the Aeronautical Systems Center, the Headquarters Air Staff, which reviewed the F-22 EA and FONSI, advised the Center against publicly releasing the FONSI because of an assumed lack of public interest.[13]

Based on these findings and the author's experience, it is apparent that public participation processes are viewed negatively within the acquisition communities of the services and that policies that restrict public information and limit outside debate of programs and of the programs' environmental issues are preferred. Because limiting public involvement is seen as "supporting the mission," Alternatives 1 and 2 which limit the scope of the EIA process are preferred when considering this value.

Others within the DoD support public participation as a fundamental principle of good management and good government. This position is reflected in the Air Force's value of "acting responsibly and openly with local communities and the public." In addition, public participation provides an avenue for peer review of the technical aspects of EIA and PPA and allow the public to express its values and preferences. Here, Alternatives 3 and 4 are strongly preferred over Alternatives 1 and 2.

Since public participation under NEPA is required by law and "complying with law and policy" is also a key Air Force value, Alternatives 3 and 4 are judged to satisfy more values on this criterion than Alternatives 1 and 2, making Alternatives 3 and 4 the preferred alternatives for public participation.

7.3.4.4 Legal Review

The procedural aspects of NEPA compliance, and to lesser extent, consideration of substantive environmental issues are reviewable by the courts. Program delays caused by

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[13]US Department of Defense. "Audit Report on Environmental Consequence Analyses of Major Defense Acquisition Programs." (Washington D.C.: US Department of Defense. Office of the Inspector General. June 1993), 15.

legal review of NEPA implementation are seen as negative by acquisition managers and by most individuals on the environmental staffs within the DoD. Delays cause program costs to increase, produce negative publicity, focus the attention of senior DoD management, and call the professional competence of DoD environmental specialists into question. Thus, any NEPA generated delays will be seen as violating the value of "supporting the mission." Since substantive review of NEPA documents is rarely successful,[14] there is little value added toward minimizing legal review by including a broader scope of information in NEPA documents. To minimize legal delays and support the mission, Alternatives 1 and 2 produce legally defensible documents at the least overall cost.

This position is somewhat offset by the Air Force's desire to "do the right thing" and to "act responsibly and openly." Should environmental analysis be structured to minimize the potential for successful legal review of acquisition NEPA documents if other values are violated in the process? As long as Alternatives 3 and 4 do not result in a substantial increase in NEPA-related litigation for the DoD, the legal review criterion should not be decisive for any of the latter three alternatives; however, based on the author's past experience with the Air Force legal staff, it should be recognized that the government's lawyers would prefer Alternatives 1 or 2 on this criterion. Thus, since this is a legal issue and values conflict, Alternatives 1 and 2 are the preferred alternatives.

7.3.4.5 Incentives to Use Analysis

In Alternatives 1 and 2, EIA is an add-on to the acquisition process that is conducted to fulfill the NEPA legal requirement. Historically, there has been little incentive to use the results of the EIA to improve decision making.

The strongest incentive to use the results of environmental analysis would probably come from increasing the level of attention given to environmental issues at the DoD level.

[14] NEPA Deskbook, (Washington D.C.: Environmental Law Institute, 1992), 23.

Implementing the criteria for the programmatic environmental assessment would be a powerful incentive to use environmental analysis.

To the degree that adding PPA increases the incentives to use environmental analysis, Alternatives 2, 3, and 4 are preferred. To the degree that structuring EIA and PPA under Alternatives 3 or 4 improves the overall integration of analysis, the relevance of the analysis to early decisions, improves public input and peer review, or improves the implementation of EIA and PPA, then these alternatives are preferred over Alternative 2.

The goal of EIA as well as PPA is to improve environmental planning and to reduce impacts. Accomplishing this goal requires an environmental presence in the day-to-day management of the program to handle routine administration of the program, coordinate with other staff members, and to advise the program manager. Thus, Alternatives 3 and 4 which encourage placement of environmental specialists within program offices are preferred. This enables programs managers to "comply with law and policy," to "provide leadership and effective management" on environmental issues, and to "act responsibly." Since Alternative 4 results in the greatest number of government environmental specialists, this alternative provides the strongest internal voice on environmental issues.

Overall, Alternatives 3 and 4 are preferred alternatives, while Alternative 1 is undesirable in providing incentives to use analysis. This conclusion is supported by the Air Force's values of "doing the right thing," "making good business decisions," "providing strong leadership and effective management," and "acting responsibly."

7.3.4.6 <u>Continued Improvement</u>

Since EIA has not historically been used for decision making, successful legal challenges have been rare, and there has been little monitoring, thus, there has been little incentive for improvement. To the degree the PPA can be used to show internal costs to DoD for environmental impacts, there is some incentive to improve. In addition, the growing proportion of the defense budget devoted to environmental issues provides a

powerful incentive from a business management point of view to improve. Based on the potential of PPA to create incentives for continuing improvement, Alternatives 2, 3, and 4 are preferred over Alternative 1 where PPA is not required.

As with creating incentives to use analysis, Alternative 4 may provide incentives for continuing improvement by utilizing additional environmental specialists; however, increasing the level of attention given to environmental issues at DoD is likely to produce the strongest incentive for improvement and this can be accomplished under Alternatives 2, 3, or 4. Increasing the level of attention given to environmental issues at DoD is not dependent on specifying how to implement PPA. The key requirement is that the information required for review as outlined in the criteria for the programmatic environmental assessment (PEA) be included. Since Alternatives 2, 3, and 4 all require changing current policy and could result in adopting the criteria for the PEA, these alternatives are clearly preferred over Alternative 1.

To the degree that integrating EIA and PPA improves the utility of formal NEPA documents, program managers will be more likely to use the analysis to provide an incentive for improvement. Thus, improvement can be encouraged by making NEPA documents more useful. This favors Alternatives 3 and 4.

The important Air Force values for continued improvement are "doing the right thing," "making good business decisions," and "providing effective management." Based on these values, Alternatives 3 and 4 are not clearly better than Alternative 2. As a result, Alternatives 2, 3, and 4 are preferred over Alternative 1 for encouraging continued improvement.

7.3.4.7 Number of Environmental Specialists

Overall, Alternative 1 requires no additional government environmental specialists. Among the alternatives that implement PPA, Alternative 2 requires the least number of government environmental specialists for implementation. This occurs because EIA can

continue to be contracted to firms that specialize in EIA and PPA can be written into prime system development contracts. As a result, little net change in the number of government environmental specialists is required.

Under Alternatives 3 and 4, the more integrated that EIA and PPA become, the more work will probably be done by the government in-house. This is because EIA cannot be accomplished by the prime system contractor. As a result, the alternative to increasing the number of government environmental specialists is to hire a contractor that would perform EIA and PPA. The disadvantage to this approach is that the contractor would have to avoid conflict of interest issues associated with having a financial stake in the outcome of the EIA.

Another alternative is to obtain contractor technical support to integrate EIA and PPA efforts in the program office. Except in the Air Force's ballistic missile development efforts, providing extensive contractor technical support to the program office has rarely been done. While funding could be provided, additional government environmental specialists would probably still be needed to oversee the contractor's work.

Because of the requirement for more government environmental specialists, Alternatives 3 and 4 would be undesirable to the Air Force based on its value of "supporting the mission." Within the Air Force, the organization has a strong desire to minimize the number of people involved in support activities and overhead activities. Since overall service manpower levels are established by DoD and Congress, minimizing support and overhead leaves more of the total manpower pie for war fighting. Having too few, support and overhead people causes management and support problems. Having too many, reduces the services ability to perform its defense mission. As a result, almost all policies that tend to increase the requirement for support or overhead personnel will be resisted.

The positive side of have more environmental specialists is that they serve as proponents of environmental values within the organization. In addition, having qualified

people in the program offices to manage environmental issues will aid compliance and provide the technical skills needed to help program managers to "do the right thing." Finally, given the small number of environmental specialists that have been employed in acquisition in the past, increasing the number of environmental specialists will encourage strong environmental leadership and management.

From a environmental point of view, Alternatives 3 and 4 are preferred. From a business point of view, Alternative 2 is preferred on the basis that increasing staffing levels is undesirable, but PPA should be accomplished. As a result, Alternatives 2 and 3 are the preferred alternatives since PPA is implemented with the fewest people.[15] Alternative 4 is undesirable for this criterion since it is so manpower intensive.

7.3.5 Select an Alternative

The results of the evaluation are summarized in Table 7.7. The table shows that Alternatives 2, 3, and 4, keeping in mind the Air Force's values, are preferred much more frequently than Alternative 1. The evaluation also shows that Alternative 3 is slightly preferred over Alternatives 2 and 4 and is recommended as the final choice.

Criteria	**Alternative 1 No Action**	**Alternative 2 Independent**	**Alternative 3 Integrated**	**Alternative 4 Single**
Focus on Important Issues	-	+	+	+
Alternatives Studied	-		+	+
Public Participation			+	+
Legal Review	+	+		
Incentives to Use Analysis	-			+
Continued Improvement		+	+	+
Number of Env. Specialists		+	+	-
Totals	-2	4	5	4

Table 7.7. Summary of Evaluation Preferences for Structuring Analysis

[15]Overall, complying with law and policy will require the acquisition community to somewhat increase environmental staffing levels without regard to the structure of EIA and PPA.

Based on this analysis, Alternative 1 is clearly inferior to the other alternatives. This strongly supports the conclusion that a micro-focused system of pollution prevention analysis should be implemented within DoD acquisition programs. In addition, DoD policy should, at minimum, encourage integration of EIA and PPA. This can be accomplished by careful review of programmatic environmental assessments and by insisting on greater public participation in the EIA process. If stronger integration as described by Alternative 3 is selected, the DoD environmental impact analysis (EIA) policy in DoD Directive 6050.1 could be changed to describe the specific changes to the EIA process. Finally, if Alternative 4 is selected, a new or complete revised DoD policy document would be needed.

7.4 Hazardous Materials Selection

7.4.1 Recognize the Problem

Perhaps the biggest challenge in approaching the issues surrounding DoD's hazardous material selection policy is trying to identify one or more root problems. As the following discussion illustrates, the policy on selecting hazardous materials is a classic case of implementation failure. What was started in Washington with great promise for reforming systems acquisition in 1989 has yet to be implemented in 1994, five year later.

To begin an analysis of the issues, it is logical to review the policy. DoDI 5000.2 requires that life-cycle costs be considered when selecting hazardous materials during the design of a system:

> The selection, use, and disposal of hazardous materials in the systems acquisition process will be managed over the system life cycle so that the Department of Defense incurs the lowest cost required to protect human health and the environment. . .
>
> Life-cycle cost estimates must include the cost of acquiring, handling, using, and disposing of any hazardous or potentially hazardous materials. . .

> Where the use of hazardous materials cannot be reasonably avoided, procedures for identifying, tracking, storing, handling, and disposing of such materials and equipment will be developed and implemented. . .[16]

While current DoD policy requires that life-cycle costs be the main criterion for selecting hazardous materials, none of the programs studied have implemented the policy. The reasons for this include both management and policy failures.

On the management side, the issues involve both planning and control. First, no one in DoD or the Air Force was put in charge of planning implementation. As a result, no implementation plan was ever developed and the workers in the program offices who should have implemented the policy were not told how to implement the policy. The workers were never trained on the methods that should be used, what costs were to be included, how to evaluate the contractor's work, or where to collect the needed historical cost data. Since they were not sure how to proceed, the program offices did not implement the policy. In addition, during program reviews, neither the Air Force nor DoD challenged the program managers concerning why the policy was not being implemented. As time when on, the program offices increasingly saw the policy as one DoD was not serious about, so they ignored it.

In industry, company managers were skeptical that an acceptable life-cycle cost model could be developed that would be useful for making design decisions and they questioned the use of life-cycle costing as the sole criterion for selecting hazardous materials. The managers were not opposed to economic analysis that considers acquisition, handling, disposal and other life-cycle costs per se, but they were opposed to selecting hazardous materials based solely on life-cycle costs. Finally, the managers were opposed to prematurely adopting a formal and uniform life-cycle cost modeling approach. Instead, they propose to use accepted methods of economic analysis, subject to available data, to guide decisions.

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[16]DoDI 5000.2, 6-I-3 to 6-I-4.

Because of their contractual relationship with the Air Force, company managers are not generally willing to publicly state their disagreement with DoD acquisition policy. To provide some protection for individual managers and companies, industry is using its Washington D.C. trade associations to carry the message. Thus, part of what was expressed in the interviews appeared in a joint letter from the Aerospace Industries Association and the Electronic Industries Association to DoD concerning DoD's policy on ozone depleting substances.[17] The letter states that, "Industry believes it is premature to mandate the use of life-cycle economic analysis."[18] On the other hand, industry argues that economic feasibility along with technical feasibility are key concerns in selecting substitutes or alternative technologies for ozone depleting substances. Industry defines technical feasibility to mean, "a substitute chemical, process, or alternative technology for which sufficient test data has been generated. . ." Economic feasibility includes, "the known potential cost associated with using substitute chemicals or alternative technology over the life cycle of the product subject to available data."

The Air Force's input to DoD for drafting a response to the associations' letter states, "Life-cycle economic analysis is necessary and warranted now in determining

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[17]LeRoy J. Haugh, Vice President, Aerospace Industries Association and Dan C. Heinemeier, Vice President, Electronic Industries Association, letter to Ms. Sherri Wasserman Goodman, Deputy Under Secretary of Defense for Environmental Security, 21 December 1993. Letter expresses appreciation for Ms. Goodman's willingness to listen to the associations member's concerns and includes an enclosure with proposed clarifications on DoD policy on ozone-depleting substances.

[18]Ibid. The letter contains the following rationale: There are no models or accepted methods to accurately project future costs and liabilities associated with the use of specific hazardous materials. At present, life-cycle cost analysis is at best a conceptual process. Current concepts which attempt to project future liabilities associated with present use of hazardous materials tend to predict large potential impacts with a totally unknown probability of occurrence. This result tends to be inconsistent with present accounting practices and principles which require cost to be estimated with reasonable accuracy and be able to predict the likelihood of occurrence of the costs. The services, EPA, and industry are working on life-cycle cost models and concepts. Yet none of these efforts have matured to the point where they would meet standard accounting practices and principles associated with predicting realistic results. Everyone recognizes the desirability of having a working model. The process is in very early stages of development and not mature enough to be applicable across a broad spectrum of industry.

courses of action regarding the elimination of ODCs."[19] On the surface, industry and the Air Force appear to have a significant disagreement, but as will be explained, the Air Force and industry are actually in basic agreement on the overall scope of economic analysis that should to be done. The problem is that neither side is using precise terminology or listening to the others' concerns.

Both the government and industry agree that direct life-cycle cost factors should be considered in selecting hazardous materials and processes. Direct cost factors include the costs associated with complying with environmental, health, and safety regulations such as handling and storage, engineering controls, reporting, disposal, etc. These costs have not been quantified in the past to support decision making. Quantifying them would represent a significant improvement over current practices.

Where the disagreement arises is in the use of the term life-cycle cost. "True" programmatic life-cycle cost estimates are routinely made in acquisition programs and are reported to senior DoD officials and to Congress. The estimates include program costs from inception to disposal and the results are audited regularly. In addition, the contractors must use government approved cost factors, estimating, and modeling techniques.

Industry objects to using true life-cycle costing for selecting hazardous materials and has some justification. For example, the F-22 program is considering whether or not to replace cadmium plating on the landing gear with another form of corrosion protection. The relevant cost information needed for decision making is the difference in future costs between using cadmium and its alternatives. The sunk costs associated with using cadmium over the past twelve years of the development program have no bearing on the

[19]Alan P. Babbitt, Deputy for Hazardous Materials and Waste, Deputy Assistant Secretary of the Air Force for Environment, Safety, and Occupational Health, information memorandum to Assistant Deputy Secretary of Defense, Pollution Prevention, "Aerospace & Electronic Industries Association (AEIA) Letter of December 21, 1993," 14 February 1994.

decision. In addition, only cost differences need to be calculated. If for example cadmium and it replacements all require annual health monitoring of workers, the actual costs for providing health monitoring need not be calculated since it will be the same for each alternative and will not impact the final decision.

Based on the fact that gathering information excess to that needed for a decision wastes resources, industry has some justification in wanting to bound decision problems so that the minimum amount of information needed to make each decision is gathered. The Air Force's comment that, "A life-cycle cost analysis can compare the relative cost impacts of using one hazardous material versus the life-cycle cost estimate of using a less hazardous material,"[20] supports the view that the Air Force is interested in comparative evaluation of costs, not in knowing the true life-cycle cost of cadmium plating.

Thus, a major portion of the issue involves a disagreement over the meaning of the term, life-cycle cost. The disagreement was caused by the DoD's and the Air Force's imprecise used of language. Clarifying the intent of the policy should be a straight forward matter.

Another potential issue with the current policy is that it establishes a cost-effectiveness framework for analysis, but incompletely defines the framework. Like the language issue, this issue could have caused implementation problems, but both the government and industry agree on what the policy writers meant to say in the policy.

Cost-effectiveness refers to a general framework for finding the lowest cost alternative for accomplishing an objective and the method is commonly used in the systems acquisition process. An example is the Cost and Operational Effectiveness Analysis[21] (COEA) which seeks to identify the most cost effective means to meet the mission requirement.

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[20]Ibid., 4.

[21]COEA is a quantitative documented examination of alternative prospective systems for eliminating the mission deficiency. The analytical process includes trade-offs among alternatives, the

According to Sugden and Williams[22], cost-effectiveness analysis tries to show how a given level of benefits can be achieved at the minimum cost, or to show how the maximum benefit can be achieved at some given level of cost. DoD's hazardous material policy clearly falls into the former category. The goal is to reduce the use of hazardous materials in order to protect human health and the environment. This benefit is to be achieved at minimum cost, where cost is defined to be the life-cycle cost.

In this framework, a clear separation is made between the life-cycle costs associated with using hazardous materials in a system and the measure of effectiveness (protecting human health and the environment). The analysis involves selecting the lowest cost alternative that can produce the desired benefit. The problem arises in trying to determine how to measure effectiveness. What measures should be used to quantify protecting human health and the environment?

In order to illustrate the issues involved, an example of a pollution prevention problem that an acquisition program might face is outlined in Table 7.8. The example is adapted from a paper by Wolf.[23] The example presents two alternatives for cleaning metal parts during maintenance of a new system.

The "direct" life-cycle costs include the costs of owning and operating the equipment, purchasing and handling supplies, health monitoring of workers, disposing of waste, etc. Potential long-term environmental liability is not included. These direct costs are clearly included in the environmental costs addressed in DoD's hazardous materials selection policy.

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measurement of the effectiveness, and cost of the alternatives. From George Sammet, Jr. and David E. Green, Defense Acquisition Management, (Boca Raton, FL: Florida Atlantic University Press, 1990), 428.

[22]Robert Sugden and Alan Williams, The Principles of Practical Cost-Benefit Analysis, (New York: Oxford University Press, 1988), 190-191.

[23]Katy Wolf, "Source Reduction and the Waste Management Hierarchy," Journal of the Air Pollution Control Association, vol. 38, (May 1988): 681-686.

ACQUISITION PROBLEM
Situation: - An acquisition program is considering alternative maintenance procedures for a new system. - The Air Force currently uses solvent "A" for cleaning and degreasing parts on the current system that will be replaced with the new system. The parts are dipped into a vapor degreaser to clean the contaminates which include metals, soils, and oils. Most of the base-level degreasers in use are old. - Because the freeboard--the height of the degreaser above the vapor zone--is very low in the old machines and because the machines do not have condensing coils, a significant amount of water vapor enters the degreasers from the air above the vapor zone. The water causes two problems. First, the solvent must be replaced more frequently than if no water were present and second, the water and solvent must be separated before the solvent can be recycled and reused. In addition, solvent vapor presents a hazard to workers.
Option 1: Purchase new degreasers and use a less toxic solvent. - The new equipment eliminates water contamination of solvent and the new solvent is less toxic to workers. - Waste streams: Solvent is recycled. Residues from the recycling process are hazardous waste. - Life-cycle cost for equipment, maintenance, solvent, recycling, and waste disposal is estimated to be $2.3 million. - Residual risks: Solvent storage and handling must be managed to prevent spills, hazardous waste must be transported, and the planned disposal method, incineration, has unquantified potential health risks to people that live and work near the incinerator.
Option 2: Purchase aqueous cleaning equipment. - Eliminates a hazardous material (the solvent) and the associated worker exposure. - Produces low concentrations of metals in the waste water due to the need for mechanical scrubbing of parts to achieve the needed degree of cleaning. - Life-cycle cost for equipment, water, and maintenance is $2.0 million (the aqueous equipment has a shorter life span and must be replaced more frequently). - Waste steams: Wastewater is discharged to sanitary sewer. - Residual risks: New wastewater regulations may cover metal content of wastewater. If this occurs pre-treatment would be required at each base increasing life-cycle costs to $3.6 million. Discharging metals to surface waters may impact local ecosystems and drinking water supplies.

Table 7.8. Example Problem for Applying Values to Acquisition Decisions

"Indirect environmental costs" are also suggested, but are not evaluated in the example. Indirect costs are those associated with long-term liability and with the residual risks Trying to deal with the indirect costs raises two questions: 1) how important are the residual risks, and 2) how are the residual risks to be evaluated (quantitatively or qualitatively)?

The first question is a value question. Industry currently considers these issues, but does so without government input as to what is important. At Lockheed Aeronautical Systems Company (LASC) a hazardous material scoring model is used to evaluate hazardous materials. The factors used in the model are shown in Table 5.3. At McDonnell Douglas Aerospace - East (MDA-E), the risk matrix shown in Figure 5.5 is used. Both methods attempt to deal with considerations that are not quantified in the firms' economic analysis. In Chapter 5, one of the weaknesses that was identified in the design-materials paradigm was that there is no government input into the criteria used in the evaluation step (this is the step where the scoring model is used). The first question above deals with the same issue. As a result of the analysis in Chapter 5, one recommendation for improving government consideration of values was already made in Section 7.2.3, where values were the subject of one of the recommended new criteria for programmatic environmental assessments. In addition to this recommendation, values will be further considered in looking at alternatives for hazardous material selection policy.

The second question concerns both methodology and the value of information, but only the latter issue is an open policy issue. Both industry and DoD agree that cost-benefit analysis and related methods, such as cost-effectiveness, should be used to aid decision making. National Aerospace Standard NAS411, "Hazardous Materials Management Program," which was developed by industry, states that trade-off analysis associated with trading a hazardous material for a less hazardous material over the life cycle of the product will include cost-benefit analysis.[24] Thus, while the policy language is again sloppy, industry and DoD both appear to have the same understanding on the general methodology that will be used in major trade-off studies. Since there is general agreement, the need to clarify the policy is not urgent, but it should done at the next opportunity to preclude future misunderstandings.

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[24] Aerospace Industries Association, National Aerospace Standard NAS411, "Hazardous Materials Management Program," (Washington D.C.: Aerospace Industries Association, 1993) 4.

What is not clear is how the indirect costs are to be evaluated. In the maintenance example, none of the indirect costs were quantified, and this would be acceptable under the current policy. Not quantifying all impacts is also within the realm of acceptable professional practice in preparing cost-benefit analysis. In describing the role of cost-benefit analysis in the decision-making process, Campen states that cost-benefit analysis,

> produces a single quantitative measure of net benefits (i.e., benefits minus costs) expressed in monetary terms. This summary measure, accompanied by descriptive analysis of other consequences not included in its quantitative valuation, is intended to provide one important input into the decision-making process rather than to determine the outcome of that process.[25]

The issue of how far to carry the cost-benefit analysis of the environmental issues associated with individual design decisions is case specific and should not be determined in advance by DoD policy; however, the issue does reinforce the need to consider values prior to making case-by-case decisions in the program offices.

A final issue with DoD's hazardous materials selection policy occurs at the detail-design level within a program and the design for environment (DFE) initiatives of industry help explain the issue. Allenby and Fullerton[26] define DFE as an effort, "to implement industrial ecology principles into a systems analysis approach to environmental management," by integrating environmental considerations[27] into product and process engineering design procedures. Implementation of DFE centers on two tools: a generic set of procedures and practices, and an information system that would summarize the relevant environmental, health, and safety; social; economic; and regulatory data.

[25]James T. Campen, Benefit, Cost, and Beyond: The Political Economy of Benefit-Cost Analysis. (Cambridge, MA: Ballinger, 1986), 92.

[26]Braden R. Allenby and Ann Fullerton, "Design for Environment - A New Strategy for Environmental Management," Pollution Prevention Review, 2, no. 1 (December 1992): 51-62.

[27]The term environmental considerations is used with its broadest meaning, to include, social, cultural, economic, and political dimensions of environmental issues.

The generic set of procedures and practices involves displaying information on environmental values in useful ways. Why is this an issue given the number of decision-aiding methods already in use?--because the current methods are not practical for day-to-day design decision making. Applying the methods requires too much time and too much effort to be economically viable for many micro-level design issues. Thus, as the decision focus narrows down from system alternatives to specific design decisions on materials and processes, economically viable methods for considering environmental values are needed.

Merkhofer would not necessarily agree with this conclusion. He believes that one of the important characteristics of formal approaches is their flexibility in the level of detail, time, and resources required; however, limited analyses place greater reliance on experts and they also require the most highly skilled analysts.[28] This means that in a limited analysis, expert opinion is used in place of objective information. How much expert opinion should DoD policy allow?

Using an example to illustrate the issue: an engineer is tasked to design a mounting bracket and one of the issues that must be decided involves choosing between nickel-plated fasteners and zinc-plated fasteners. The engineer has a week to complete the design. How should environmental considerations be addressed in making the selection?

DoD's policy states that the environmental costs to DoD over the product's life cycle are important and must be considered along with other cost factors. What else is important and should be considered in the limited time available? While mechanical fasteners have worked well in the past, should adhesives be explored? The problems associated with having limited time and resources for environmental analysis is a root problem facing designers at the micro-level. Given the limited time available, determining what is important becomes a critical issue.

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[28]Miley W. Merkhofer, Decision Science and Social Risk Management: A Comparative Evaluation of Cost-Benefit Analysis, Decision Analysis, and Other Formal Decision-Aiding Approaches, (Dordrecht, Holland: D. Reidel Publishing, 1986), 197.

The cadmium issue on the F-22 and the maintenance example on cleaning and degreasing parts both involve sufficiently large technical and life-cycle cost issues that a trade-off study would be conducted to determine the best course of action. In these cases, a cost-benefit analysis is required and should be accomplished. The fastener example is meant to illustrate another class of design problems. These problems represent the majority of micro-level, detail-design decisions that are not subject to formal trade-off studies. This issue concerns the degree of analysis that should be applied to this class of design decisions.

In conclusion, a number of problems were identified that contribute to the Air Force's failure to implement DoD's hazardous material selection policy. First, there are management planning and control problems. Second, there is a communication problem that has caused confusion over the meaning of, "life-cycle cost." This can be easily corrected by revising the policy to be more precise. Third, there is no requirement to assess or to provide contractors information on the government's environmental values, which provide a basis for deciding what is important. Fourth, the policy establishes a cost-effectiveness analytic framework that is unclear. This should be clarified to include the entire family of cost-benefit methods. Finally, the policy is being applied equally to all hazardous material design decisions, but the literature and experiences of the companies studied suggest that there are two classes of design issues. The first class involves major design decisions that are supported with formal trade-off studies. For this class of problems, cost-benefit analysis and its variations are the accepted methods of analysis by both industry and government for meeting the requirements of DoD's hazardous materials selection policy. The second class involves day-to-day detail-design decisions. On this scale, formal cost-benefit analysis methods become very resource intensive.

As a result of this analysis, two policy issues will be addressed: 1) how should environmental values be incorporated in the acquisition process, and 2) should a two-level

system of analysis be implemented that allows alternative methods to be used for considering hazardous materials at the detail-design level.

7.4.2 Specify Values

The six Air Force pollution prevention values listed in Section 7.3.2 will be used to evaluate this issue; however, unlike the analysis of an appropriate structure for EIA and PPA where a set of criteria were developed from the pollution prevention framework, the evaluation of this issue involves evaluating two separate policy issues. The first issue concerns selecting values and the second issue concerns selecting decision-aiding approaches.

For the values issue, a set of criteria suggested by Andrews and Waits[29] for giving "appropriate" consideration to environmental values[30] in public decisions will be used. Andrews and Waits were interested in how substantive balancing of environmental values and non-environmental values can be accomplished.[31] This is the same concern that is raised here concerning DoD's policy. In order to achieve appropriate consideration, Andrews and Waits' conclude that at least four criteria are important:

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[29]Richard N. L. Andrews and Mary Jo Waits, Environmental Values in Public Decisions: A Research Agenda, (Ann Arbor, MI: School of Natural Resources, The University of Michigan, April 1978), 16-21.

[30]Ibid., 9-10. Andrews and Waits believe that values are not objects that can be listed and counted; a value is, rather, a statement of relationship, an estimation of worth of some object to an individual or in a particular situation: of means to end, of resource to beneficiary, of environmental condition to organism. The value relationship may take three forms: preference, obligation, and function. Preference is a relationship of individual desire: I like one ecosystem more than another, solitude more than crowds, or fishing more than water skiing. Obligation is a relationship of social norms: Americans are expected to honor the norms of picking up one's own litter, not contaminating water supplies, respecting others' rights. Function is a relationship of usefulness or service or system maintenance: stratospheric ozone is valuable because it protects biological life, and fertile soil is valuable to a society because it provides a source of food.

[31]Ibid., 15. Andrews and Waits argue that, "contrary to common assumptions, then, the question is not quantification per se, but appropriate representation of each environmental value. Quantification is a matter of degree. . .The question is to determine what sort of quantification is appropriate to each value, the nature of the indicator, and its level of precision."

1. Do proper procedures insure that all relevant values are at least consciously identified?
2. Are the values expressed in terms of valid indicators, measurements, and inferences?
3. Has enough information been gathered to permit responsible choice, and does it reach the right audience at the right point?
4. Does the decision reflect an appropriate ordering and weighting of environmental values with other social norms?[32]

The first two criteria are critical to this issue and will be used in evaluating policy alternatives. The latter two criteria can only be evaluated in conjunction with specific decision situations during implementation which makes them inappropriate for use in looking at DoD policy; however, they do provide an interesting set of questions for future audits of acquisition programs.

For evaluating decision-aiding methodologies, the criteria suggested by Merkhofer will be used. Merkhofer[33] categorizes criteria for evaluating decision-aiding approaches as internal and external. Internal criteria involve considerations that are within the domain of analysis. This includes logical soundness, completeness, and accuracy. External criteria are imposed by considerations normally thought to be outside the disciplines of analysis, particularly the desires and constraints imposed by decision makers and the public and objective limitations of time and resources. External criteria include practicality and acceptability. Since the policy alternatives to be considered do not include selecting a specific approach, only the external criteria will be used to evaluate the policy alternatives.

7.4.3 <u>Create Alternatives</u>

The five alternatives shown in Figure 7.7 will be considered.

Alternative 1, the no action alternative, retains the existing policy. Alternatives 2 through 5 involve two policy choices. The first choice involves how environmental values will be determined. The second choice involves whether a single system of analysis (cost-

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[32]Ibid., 19-20.

[33]Merkhofer, 189-192.

benefit and related formal methods) as required in the existing policy should be used for all hazardous materials decisions or whether a second level of less-formal analysis should be specifically allowed for detail design issues that are not supported with a formal trade study.

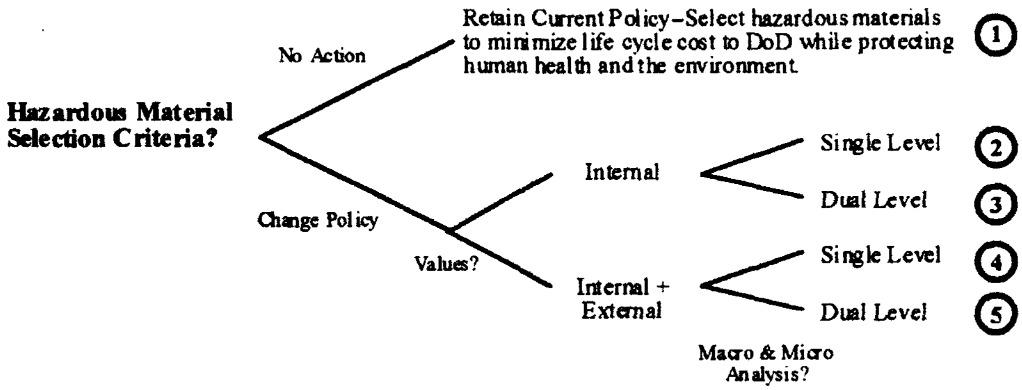

Figure 7.7. Hazardous Material Selection Policy Alternatives

The alternatives associated with determining values are labeled as "internal" and "internal + external" in Figure 7.7. The "internal" alternatives would provide a minimum listing of criteria that must be considered in making balanced program decisions and the policy would encourage the addition of other criteria by the program manager. The minimum criteria list would include all direct environmental, health, and safety costs. Quantification would be required for all significant, direct costs that are relevant to decision making. Public input would be obtained in the process of developing the DoD policy. The values selected and their indicators would be included in the programmatic environmental assessment.

The "internal + external" alternatives require the same minimum values listed for the "internal" alternatives, but would establish procedures for getting input from internal and external to DoD in the process of selecting a final set decision criteria (or values). Final selection of specific decision criteria and indicators would be left to individual program

managers. The actual values selected and their indicators would be included in the programmatic environmental assessment.

The alternatives associated with the macro and micro-analysis methodologies are labeled as "single" and "dual." Under the "single" alternatives, the cost-benefit family of analysis methods would be used to support all hazardous material selection decisions and the problems associated with the current policy would be clarified. This includes fixing the life-cycle cost language and clarifying the implied reference to a cost-effectiveness decision framework so that it allows use of the most appropriate method within the risk-cost-benefit family of methods. The "dual" methods, would require cost-benefit analysis in all trade studies, but would allow programs to adopt other systems of analysis for detail-design level decisions. Methods adopted would be described in environmental impact analysis process documents and also in the programmatic environmental assessment.

7.4.4 Evaluate Alternatives

The five alternatives will be evaluated by comparing how well the alternatives meet Andrews and Waits' value criteria and Merkhofer's external criteria for decision-aiding methodologies. The Air Force's pollution prevention values will be used to select a preferred alternative for each criteria. The results will then be summarized in Section 7.4.5.

7.4.4.1 Procedures to Identify Relevant Values

Before evaluating the alternatives against the criteria--do proper procedures insure that all relevant values are at least consciously identified?--a short review of the sources of values is presented. "Value considerations enter into administrative decisions from three principal sources: laws, political pressures, and administrative judgments."[34] In systems

[34]Andrews and Waits, 18.

acquisition, all three sources are common. Relevant laws and regulations include both the environmental laws and regulations that impact a specific decision as well as the procedural laws and regulations that govern systems acquisition and environmental impact analysis. Some values arise through pressures exerted by individuals and groups internal and external to DoD. This includes DoD managers, congressmen, industry associations, interest groups, and others. Finally, project managers have their own values which they apply in making decisions. In evaluating the alternatives, all three sources of values are considered.

In Alternative 1, the no action alternative, the current policy includes a set of minimum values. The policy states that, "Life-cycle cost estimates must include the cost of acquiring, handling, using, and disposing of any hazardous or potentially hazardous materials. . ."[35] The policy specifically requires that costs associated with compliance requirements be included in life-cycle cost estimates. This means that the law is included as a source of values. The policy also includes other reasonable environmental, health, and safety costs that are prudent, but that may not be explicitly required by law. The program manager may ask for additional information based on personal values, but is tasked to select the option that incurs the lowest cost to DoD that will protect human health and the environment. Since the legal values inherent in the problem are included in the life-cycle costs, the existing policy puts great weight on the program manger's personal values.

Under Alternatives 2 and 3, the "internal" alternatives, the direct life-cycle costs that are required in the current policy would be retained and possibly supplemented with additional values. In these alternatives, the policy writers' values will be supplemented by the program manger's values and values generated by internal DoD political pressures. In

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[35]US Department of Defense, Department of Defense Instruction (DoDI) 5000.2, Defense Acquisition Management Policies and Procedures, (Washington D.C.: US Department of Defense, 23 February 1991), page 6-I-3.

addition, the public would have input into the minimum set of values prior to final publication of the policy. These alternatives allow the program manager the greatest freedom of action and require less administrative procedures than the "internal + external" alternatives. Both qualities are highly desirable in efforts to streamline and improve the acquisition process. The negative side of these alternatives is that environmental values can be determined solely by the program manager with minimal outside input.

In the "internal + external" alternatives, Alternatives 4 and 5, the same set of minimum life-cycle cost values would be required, and in addition procedures for explicitly considering environmental values would be created. This would provide a form of audit trail back the source of the values and would probably result in the broader consideration of environmental values within programs at an early stage. In addition, the process helps to ensures that relevant environmental values are identified; however, the program manager's values and those due to internal DoD policies will probably still receive the most weight.

All of the alternatives are adequate for meeting the Air Force's values for "complying with law and policy" and "doing the right thing." Since some in DoD and the Air Force view public input as undesirable in that it has the potential to produce negative publicity for a program, Alternatives 1, 2 and 3 are preferred for "supporting the mission."

Since, part of "making good business decisions" involves preventing future liabilities, the preference for this value depends on whether, and to what degree, future liabilities are included in the environmental values. Based on industries' resistance to current methodologies for including liabilities in life-cycle costs, Alternatives 4 and 5 are preferred since they would be more likely to include values that address specific types of potentially significant liabilities.

Providing "effective management" involves both having an effective acquisition process and considering a wide set of environmental values in decision making. Alternatives 2 and 3 keep administrative procedures to a minimum and require values to

be identified. In the acquisition process, reducing over-regulation has been a key recommendation of acquisition reformers. As a result of this long-held bias towards fewer acquisition regulations both within DoD and among most serious acquisition writers outside the DoD, policies that include new procedural requirements are usually viewed with deep suspicion. Alternatives 4 and 5 require additional procedures, but will probably also result in the widest consideration of values. The poor language used in Alternative 1 makes it undesirable. Finally, based on "acting openly and responsibly with the public," Alternatives 4 and 5 are clearly the most desirable.

Because of the strong value conflict that results from having more acquisition procedures on the one hand and having greater public input on the other, none of the alternatives is clearly preferred, but Alternative 1 is undesirable.

7.4.4.2 Values Expressed in Terms of Valid Indicators

When looking at values being expressed in terms of valid indicators, there is little or no difference between Alternatives 1, 2 and 3. Beyond the minimum requirement to consider life-cycle costs, the policies do not provide any assurance that values will be expressed in terms of valid indicators. Since Alternatives 4 and 5 have procedures for considering values and indicators, these alternatives would be more likely to produce valid indicators for values.

In applying the Air Force values to this criteria, Alternatives 4 and 5 are preferred in every case. Having valid indicators is a requirement for "supporting the mission," "complying with policy," "doing the right thing," "making good business decisions," "providing effective management," and "acting responsibly." This makes Alternatives 4 and 5 the clearly preferred alternatives.

7.4.4.3 Practicality of Methods

According to Merkhofer, practicality means that the analysis can be conducted in the real-world, problem-solving environment using available resources and information.

> Basically, this requires that a pool of expertise be available to implement the approach and the costs, time, and effort required are appropriate and compatible with the constraints of the situation.[36]

Under both the single level and dual level proposals, significant, direct, life-cycle cost factors will be evaluated for every hazardous material decision. This is required by the minimum criteria. Thus, the alternatives address how the indirect and residual risks that were identified in Table 7.8 will be handled.

Alternatives 2 and 4, the "single" alternatives, maintain the current cost-benefit framework. Since the current cost-benefit framework allows descriptive analysis of some consequences not to be included in the quantitative valuation, there seems to be little reason to allow another system of analysis. On the other hand, quantifying only the direct costs for detail design decisions would seem to be beyond a reasonable definition of cost-benefit analysis.

Under Alternatives 2 and 4, evaluating the direct cost data and presenting all of the indirect cost data as Lockheed has done in their risk scoring model would not be allowed. This would result in additional time, costs, and effort for making decisions.

Alternatives 3 and 5, the "dual" alternatives, would allow a second, less formal system of analysis, to be used for decisions that are not supported with a formal trade-off study. This policy would recognize that at the detail level, most if not all, indirect and residual risks would be evaluated qualitatively. This would prevent confusion and would encourage innovative ways for displaying this information. The weakness of this these alternatives is that DoD policy would have to be written to distinguish between the two levels of analysis and rules would be needed to explain when each system of analysis would be allowed. This need for additional rules is a significant negative factor.

Based on the above analysis, the Air Force's value of "effective management" makes the "dual" alternatives less desirable than the "single" alternatives because of the need for

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[36]Merkhofer, 191.

additional rules. The Air Force's value concerning "making good business decisions" supports the "dual" alternatives where new or better methods of considering environmental values are encouraged, and time and information constraints are recognized. Overall, neither the "single" alternatives nor the "dual" alternatives are clearly preferred based on this criteria; however, Alternative 1 is relatively undesirable since its confusing language fails to establish a practical system of analysis.

7.4.4.4 Acceptability of the Method

Acceptability involves the desires of the decision makers, public perception of the approach, and compatibility with existing institutional norms. Since the system for hazardous materials selection has not been implemented, the method must be seen as unacceptable to many of the implementers in both industry and government. This view is supported by industries' on-going concerns with the current policy, but changing to a "dual" system of analysis will not necessarily change this situation.

Given the public debate on design for environment initiatives and on the use of cost-benefit analysis in other circumstances, there does not appear to be a clear public choice for either the "single" or the "dual" alternatives.

From an organizational viewpoint, there is a strong DoD preference for cost-benefit based analysis such as life-cycle costing. This internal DoD preference would tend to favor the "single" alternatives. The Air Force's value for "making good business decisions" includes the idea that cost is key. This value supports the "single" alternatives in that environmental impacts are expressed in terms of costs in cost-benefit analysis. This value together with the value of "effective management" tend to favor the "dual" alternatives to the degree that they are less costly to implement. Once again, Alternative 1 is undesirable and there is no clearly preferred choice among the remaining four alternatives.

7.4.5 Select an Alternative

The results of the evaluation are summarized in Table 7.9.

Criteria for Values	Alternative 1 Current Policy	Alternative 2 Internal – Single	Alternative 3 Internal – Dual	Alternative 4 Internal + External – Single	Alternative 5 Internal + External – Dual
Identification Procedures	-				
Valid Indicators Used				+	+
Practicality	-				
Acceptability	-				
Totals	**-3**	**0**	**0**	**1**	**1**

Table 7.9. Summary of Evaluation Preferences for Hazardous Material Selection

Alternative 1, the no action alternative, maintains the current policy and is undesirable based on three of the four criteria. Alternatives 2, 3, 4 and 5 are all acceptable, but Alternatives 4 and 5 score higher in the evaluation based on the criterion of producing valid indicators.

The analysis did not produce a clear policy preference because the criteria raise issues that produce conflicts among one or more of the Air Force's pollution prevention values. In order to resolve this situation, some prioritizing of the values for the issues presented is necessary.

The analysis does establish that the current policy is undesirable and it also identifies areas that any new policy should address.

CHAPTER VIII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Overview

The summary, conclusions, and recommendations are presented in four parts. First, a short overview of the research is presented. Second, the overall conclusions and recommendations are discussed. Third, the implications of the research for three broader areas of study are examined, and finally, some thoughts and recommendations for future research are offered.

The objective of this research was to explore the issues associated with implementing pollution prevention in systems acquisition programs. Information was gathered by studying pollution prevention implementation at four large aerospace companies and by studying the systems acquisition process. Given the dual focus of this work, 1) on the pollution prevention in the aerospace industry, and 2) on pollution prevention in systems acquisition, the conclusions and recommendations will address each area separately. This allows information on the aerospace industry, which may be broadly applicable to pollution prevention in general, to be clearly distinguished from the conclusions and recommendations on the system acquisition process.

8.2 Conclusions and Recommendations on Pollution Prevention in the Aerospace Industry

Conclusions on pollution prevention in the aerospace industry fall into four general areas: 1) objectives, strategies, and policies, 2) pollution prevention paradigms, 3) contextual factors, and 4) company pollution prevention implementation.

8.2.1 Objectives, Strategies, and Policies

Pollution prevention policies can be written to address all three types of basic corporate objectives: products and markets, financial and profitability, and social and psychological. At the corporate level, all of the companies studied frame pollution prevention only as a social objective. This failure to establish pollution prevention objectives that include "green" products and financial requirements along with good neighbor ideals, hinders the integration of pollution prevention concepts into the design of new products.

8.2.2 Pollution Prevention Paradigms

Industry is implementing pollution prevention using three paradigms with different starting points for analysis: 1) wastes, 2) design materials, and 3) environmental regulatory compliance. In addition, the paradigms ask different questions, require different information for analysis, involve different people, and often, produce different results.

The waste-reduction paradigm is based on the waste minimization concept and is the most widely used of the three paradigms. Analysis begins at the "end-of-the-pipe" with the wastes and works backward from the end of the manufacturing process toward the beginning. Two examples of initiatives that are based on the waste-reduction paradigm are the EPA 33/50 Program and the individual company hazardous waste reduction programs. Organizationally, the environmental management function is responsible for implementation at all four companies. An important characteristic of the paradigm is that it often leads to efforts to reduce waste by controlling the processes that produce the waste instead of looking further back up stream in the product life cycle--at the product design. Because of this, product designers are rarely involved.

The design-materials paradigm focuses attention on the materials selection process at the beginning of design. In this paradigm, analysis proceeds in a forward direction from design, to manufacturing, to customers, to wastes. Because of this, the wastes and

environmental impacts associated with selecting a material during the design process are not always well understood. In order to assess the potential impacts, an environmental impact analysis process is needed. This forward analysis process is more uncertain and requires a much greater amount of information than the backward analysis process associated with the waste-reduction paradigm. Another important difference between these two paradigms is that the design-materials paradigm focuses on the design process.

The compliance paradigm looks at environmental compliance regulations as opportunities for applying source reduction techniques. The effort is often centered in the environmental management function, but other functional areas may have a leading role as well. The paradigm uses the cost associated with coming into compliance with environmental regulations as an opportunity cost that can be applied to pollution prevention. Because the compliance regulations impose significant administrative costs in addition to addressing wastes and technologies, this paradigm has a broader scope of analysis than the waste-reduction paradigm. In the compliance paradigm, administrative and management processes are also included.

In examining how the paradigms are being implemented in the acquisition programs managed by each company, the analysis shows that one or more government inputs are absent in each program (including environmental requirements, criteria, and goals) reducing the effectiveness of each approach. Finally, the acquisition process does not recognize the dynamic nature of environmental regulations in the U.S.

8.2.3 Contextual Factors

Seven implementation contextual factors were studied--1) organizational structure, 2) communications, 3) resources, 4) dispositions, 5) decision making, 6) goal structure, and 7) the knowledge base--and two of the factors were found to be the sources of many of the continuing implementation challenges in the companies studied: organizational structure and resources.

Organizational structure is a challenge because pollution prevention must be integrated across many functions and programs. In order to meet this challenge, many organizational techniques are being employed. The techniques observed include: revising existing functional responsibilities, creating a new functional staff, adding new technical specialists to matrix management arrangements, and using committees, teams, and boards. At the companies studied, none of the techniques has been fully successful in achieving the degree of integration needed

At both LASC and LFWC, the integration structures (committees, teams, and boards) are able to accomplish specific integration tasks, but are not well suited to integrating among functions and programs on a comprehensive basis. MDA-E and P&W have developed new functional arrangements to try to cope with the need for more comprehensive integration; however, since the initiatives are still new, the effectiveness of the efforts is not yet entirely clear.

At MDA-E a new function, Environmental Assurance, was created as a multi-disciplinary, multi-functional core business unit that is staffed with engineers, managers, logisticians, and scientists. The staff assigned to Environmental Assurance also have diverse professional experiences, including program management, design and testing, environmental management, research and development, production, and logistics. Because of this makeup, Environmental Assurance is unique among the organizational structures studied and significant because it attempts to overcome functional barriers using a dedicated multi-disciplinary team.

At P&W, design responsibility for pollution prevention in new products has been assigned to Material Engineering. Responsibility for facility pollution prevention is assigned to the environmental management function. This split recognizes key differences in implementation methodologies and technical backgrounds that are needed to implement pollution prevention in the different areas.

Resources represent a key constraint for pollution prevention implementation in the aerospace industry. The industry has been down sizing for several years and finding resources to expand pollution prevention efforts has been difficult. Except at MDA-E where staffing has increased, environmental staffing has neither grown nor dropped. Since the work load associated with environmental compliance has continued to grow, pollution prevention activities are being delayed. In addition, the companies have all funded internal research and development efforts as well as pollution prevention projects for reducing releases. While this shows a strong commitment to environmental objectives, the level of effort still falls short of what managers in each company acknowledge is needed.

In addition to their internal resource limitations, the government has provided very limited funding for pollution prevention activities in the program contracts, forcing the companies to fund most activities from corporate overhead. Many in industry believe the government wants pollution prevention but wants industry to pay for implementation. For pollution prevention to succeed in acquisition programs, the government must recognize the programmatic costs and fund them.

One especially costly area for the government is its technical documentation. In preparing proposals for the Government on ODC elimination, MDA-E has discovered that the cost to change a program's technical documentation far exceeds the costs of finding and implementing the changes. While in the short term this is a funding problem because of the deadlines associated with ODC phase out, in the long term, the technical documentation systems should be redesigned to reduce the costs associated with making changes.

8.2.4 Company Pollution Prevention Implementation

The pollution prevention programs at the four facilities are well organized and with the exception of MDA-E, have made good progress in reducing emissions. Reductions in the release of the toxic release inventory (TRI) chemicals included in the EPA 33/50

Program range from high of 76 percent at LASC and LFWC, to a low of 4 percent at MDA-E, based on 1992 TRI data and using a 1988 baseline.

There are several important factors that help explain this wide difference in reductions. The first factor involves the corporate history on regulatory compliance issues. The companies that have had the most problems with their environmental regulatory agencies also tend to have the strongest records in achieving pollution prevention success. The second factor, the relative length of time the pollution prevention program has been in place, is related to the first factor. At MDA-E, the increased level of environmental concern that led to the creation of the Environmental Assurance (EA) function is relatively new. EA is less than two years old. This is too short a time for the function to have a major impact on the company's toxic release inventory releases.

Another important factor for implementing pollution prevention in acquisition programs is having a successful facility-based pollution prevention program. Many of the techniques and skills and much of information needed for identifying and evaluating facility-based pollution prevention alternatives are also required to evaluate program-specific design alternatives. In order to use this natural synergism, industry developed National Aerospace Standard 411, "Hazardous Materials Management Program," to encourage tight integration of facility-wide pollution prevention efforts and the specific requirements of individual acquisition programs.

8.3 Conclusions and Recommendations on Pollution Prevention in the Systems Acquisition Process

An integrated pollution prevention framework was used to evaluate pollution prevention in the system acquisition process. The framework's three components are: 1) pollution prevention--the principles of life-cycle design, 2) system engineering and design--the requirements for a new system design control technique, and 3) environmental impact analysis--the standards of analysis required for improving organizational intelligence.

In presenting the conclusions and recommendations on pollution prevention in the systems acquisition process, each component is first addressed individually. Then, the overall systems acquisition process is considered and specific recommendations are discussed.

8.3.1 Pollution Prevention Principles

The pollution prevention principles[1] are being partially implemented in the programs studied. This has resulted in limited success in the pollution prevention efforts observed. Implementation of the life-cycle design principle has been given the least attention, although this approach is well established in DoD policy.

The use of integrated product development is also well established in DoD policy, but the integrated product teams observed have not been fully effective in implementing pollution prevention. Three reasons for this were identified: 1) pollution prevention is not a design requirement, 2) design guidelines and tools do not address environmental issues in a useful way for designers, and 3) the necessary technical specialists within the company are not effectively integrated into the integrated product development process. Solving these problems will require action by both industry and government.

8.3.2 System Design and Engineering

In order to integrate pollution prevention into the systems design and engineering process, each environmental concern must be defined in a way that allows engineering analysis. A review of the requirements in system development contracts and of the programs' system engineering documentation shows that the only environmental requirements that meet the criteria for a system variable are associated with jet engine contracts. As a consequence, most environmental variables are not managed on a systems

[1]The pollution prevention principles include: 1) using life-cycle design, 2) including environmental requirements early in development, 3) using cross-disciplinary teams, and 4) recognizing environmental impacts as a measure of quality.

basis and the management tools that have been put into place to management system requirements, costs, and responsibilities are not being applied to environmental concerns.

The successful incorporation of air emissions and noise requirements into systems design and engineering process for jet engines shows that well-defined environmental requirements can be managed on a systems basis. This challenges the government to do a better job of precisely defining the environmental variables it wants to control and to provide a means for measuring performance.

8.3.3 Environmental Impact Analysis

The environmental impact analysis (EIA) process in systems acquisition has three major limitations: 1) EIA is an add-on process, 2) EIA is not continuous, and 3) EIA is too focused on site-specific impacts.

The first two limitations of EIA are closely related and they stem from a common misunderstanding among acquisition managers that EIA is a document that is needed before major milestone reviews[2] rather than a planning process that must be integrated into the overall acquisition process.

One result of the misunderstanding is that EIA is being implemented as a discrete, non-continuous system of analysis that takes place immediately prior to decision milestones. As long as this is the case, EIA can not become an effective environmental planning process.

Another result of this misunderstanding is that relatively few environmental specialists are employed. Those that are employed are usually assigned to a small core support function where they supervise contractor-performed EIA studies. As a result of the small number of environmental specialists and their organizational placement, environmental specialists have never been integrated into the acquisition process and EIA

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[2]The Navy's denial of NEPA's applicability to milestone decisions supports this conclusion.

is not an effective environmental planning tool for the programs. As a result, opportunities to prevent pollution have largely been lost in the systems acquisition process. This is a fundamental problem.

The third limitation involves a misunderstanding about the purpose of EIA during the early phases of system acquisition programs. As currently implemented, the EIA process in systems acquisition parallels the process used in development projects, where EIA is principally concerned with predicting the site-specific environmental impacts. Since neither the manufacturer nor the operating bases for alternative systems are known early in the acquisition process, it is nearly impossible to assess the spatial component of potential environmental impacts until the engineering and manufacturing development (EMD) phase of most programs. Because EIA is focused on spatial impacts of macro-level alternatives, little information that can materially affect the system requirements, the system design, or the early program milestone decisions is being developed. To overcome this limitation, a broadened system of environmental analysis is needed which includes micro-focused pollution prevention analysis. The broadened system of analysis would include preventing pollution through analysis of source reduction and recycling opportunities.

In addition to the three major limitations, there are also several EIA implementation problems. First, there is little public input into the EIA process even though this is one of NEPA's primary goals. Second, many environmental assessments and environmental impact statements appear to be prepared to fulfill NEPA's legal requirements rather than to inform decision making. Potential pollution prevention actions were only rarely discussed in the NEPA documents reviewed. In the case of NEPA documents prepared to support basing actions, one can conclude that the writers of the documents were either not looking for pollution prevention and mitigation opportunities or were directed not to include them.

8.3.4 The Systems Acquisition Process

A number of problems were discovered that are impacting pollution prevention implementation. First, key government inputs needed to plan and execute an effective pollution prevention program are not being provided to system contractors. The missing inputs include environmental requirements, criteria, and goals. Second, the acquisition process does not adequately consider the dynamic nature of environmental regulations or require that environmental compliance requirements at operating locations be explicitly recognized as a design constraint. Third, a system of pollution prevention analysis has not be integrated into the acquisition process. Fourth, DoD's hazardous material selection policy is not being implemented.

In considering these problems, the first two were found to be related. Recommendations for addressing them involve establishing a set of criteria at the DoD-level for reviewing the environmental performance of programs. This would provide a means for ensuring that the missing information is provided and that environmental compliance requirements are adequately addressed. The third and fourth problems are addressed individually.

8.3.4.1 The Programmatic Environmental Assessment

Each acquisition program is required to prepare a programmatic environmental assessment (PEA) that is provided to decision makers prior to milestone reviews. While the PEA was intended to be an executive summary of a program's environmental impact analyses (EIA), the limited scope of EIA in acquisition programs has prevented the assessment from being an effective decision-aiding tool. In addition, no one in the acquisition process understands what is expected in a PEA, how to evaluate a PEA, or how to use a PEA.

Conceptually, the PEA is intended to integrate all environmental analyses into a single, objective, executive-level summary document to support decision making. Given

this broad, but undefined scope, many of the deficiencies in the current acquisition process can be corrected by providing a clear set of criteria for the PEA.

To accomplish this, the scope of the PEA should be defined to include both macro and micro-focused environmental analyses. This means that the PEA should address both macro-focused environmental impact analysis (EIA) and micro-focused pollution prevention analysis (PPA). In addition to defining the PEA's overall scope, PEA criteria are needed that will provide a basis for evaluating individual programs and that will serve to define the issues PEA's must address to fulfill the document's overall purpose.

During this research, nine PEA criteria were identified that cover the following topics: 1) integration of EIA and PPA, 2) environmental impact analysis, 3) public input and comment, 4) environmental values, 5) environmental compliance regulations, 6) pollution prevention requirements, 7) pollution prevention goals, 8) new technologies, and 9) monitoring.

By adding the nine criteria to the general requirement to prepare a programmatic environmental assessment (PEA), future PEAs will not only contain information covered in a program's environmental impact analysis, but they will also include information on the program's broader environmental management efforts. By addressing both environmental impact analysis (EIA) and pollution prevention analysis (PPA), a more complete picture of a program's environmental status will be provided and the resulting PEAs should allow senior managers to focus on the important environmental issues at each milestone.

8.3.4.2 Structuring Pollution Prevention Analysis

Environmental impact analysis, as required by the National Environmental Policy Act (NEPA) has not been an effective means for accomplishing pollution prevention in systems acquisition programs. To correct this problem, a broader system of environmental planning could be instituted that includes environmental impact analysis and pollution prevention analysis.

In evaluating this issue, four alternatives for structuring environmental analyses were considered. The alternatives were evaluated on seven criteria: 1) focusing on important issues, 2) alternatives studied, 3) public participation, 4) legal review, 5) incentives to use analysis, 6) encouraging continued improvement, and 7) number of environmental specialists needed.

The results of the evaluation, which are based on the Air Force's pollution prevention values, show that distinct but closely related and integrated systems of EIA and PPA should be established. In reaching this conclusion, the recommended alternative was among the preferred alternatives on five of the seven criteria. The two areas where other alternatives were preferred were legal review and incentives to use analysis. Concerning legal review, integration of EIA and PPA could result in more information being put into formal National Environmental Policy Act (NEPA) mandated documents. Because of this, the probability for heightened public concern and more legal challenges to NEPA-required documents was judged to increase. Since this might increase the chance of program delays and add cost, alternatives that did not change EIA implementation were preferred on this criteria. The recommended alternative was strong on incentives to use analysis but was not rated as highly as a fully integrated system of EIA and PPA.

Finally, some general conclusions from the analysis were made: 1) DoD policy and procedures should be written to ensure that pollution prevention analysis (PPA) is undertaken as a part of every program; 2) DoD policy should, at minimum, encourage integration of EIA and PPA;[3] and 3) the DoD environmental impact analysis policy should be updated to reflect the changes.

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[3]This can be accomplished by carefully reviewing programmatic environmental assessments and by insisting on greater public participation in the EIA process.

8.3.4.3 Hazardous Materials Selection

DoD's policy on selecting hazardous materials has not been implemented even though the policy was formally issued in 1989. In analyzing why the policy has not been implemented in the Air Force, a number of problems were identified. First, there are management planning and control problems. Second, there is a communication problem that has caused confusion over the meaning of, "life-cycle cost." This can be easily corrected by revising the policy to be more precise. Third, there is no requirement to assess or to provide contractors information on the government's environmental values, which provide a basis for deciding what is important. Fourth, the policy establishes a cost-effectiveness analysis framework that is unclear. This should be clarified to include the entire family of cost-benefit methods.

Finally, the policy is being applied equally to all hazardous material design decisions, but the literature and experiences of the companies studied suggest that there are two classes of design issues. The first class involves major design decisions that are supported with formal trade-off studies. For this class of problems, cost-benefit analysis and its variations are the accepted methods of analysis by both industry and government for meeting the requirements of DoD's hazardous materials selection policy. The second class involves day-to-day detail-design decisions. At this scale, formal cost-benefit analysis methods become very resource intensive.

As a result, two policy issues were addressed: 1) how should environmental values be incorporated in the acquisition process, and 2) should a two-level system of analysis be implemented that allows alternative methods to be used for considering hazardous materials at the detail-design level. To evaluate the alternatives, four criteria were adopted, two for each issue. The criteria for environmental values include procedures for identifying values and using valid indicators. The criteria for systems of analysis were practicality and acceptability.

In all, five alternatives were considered. Alternative 1 was the no action alternative. Alternatives 2 through 5 involve two policy choices. The first choice involves how environmental values will be determined. The second choice involves whether a single system of analysis (cost-benefit and related formal methods) as required in the existing policy should be used for all hazardous materials decisions or whether a second level of less-formal analysis should be specifically allowed for detail design issues that are not supported with a formal trade study.

The analysis did not produce a clear policy preference; however, no action alternative was found to be undesirable in comparison with all four of the other alternatives studied. A clear choice could not made because the criteria raise issues that produce conflicts among one or more of the Air Force's pollution prevention values. In order to resolve this situation, some prioritizing of the values for the issues presented is necessary. The analysis does establish that the current policy is undesirable and it also indicates that policy alternatives that increase public input into the EIA process are desirable.

8.4 Broader Implications

Many of the conclusions and recommendations from this research are relevant to broader areas of study. In this section, the relationship of this research to three relevant areas will be discussed: 1) organizations, 2) policy implementation, and 3) defense acquisition.

8.4.1 Organizations

The integrated product development concept that is being implemented in the aerospace industry has resulted in strong matrix[4] organizations[5] and this structure has a

[4]In describing matrix organizations the terms "weak" and "strong" refer to the balance of power between project and functional managers (see Figure 8.1). In a weak matrix, the balance of power is shifted toward the functional managers, and in a strong matrix, the balance is shifted in the project manager's direction.

number of consequences for integrating pollution prevention into system acquisition programs. One important consequence of the shift from a balanced matrix to a strong matrix organizational structure is that the relative level of formal authority for project managers has increased.

Cable and Adams found that there is an inverse relationship in power between functional managers and project managers in various organizational structures as illustrated in Figure 8.1.[6]

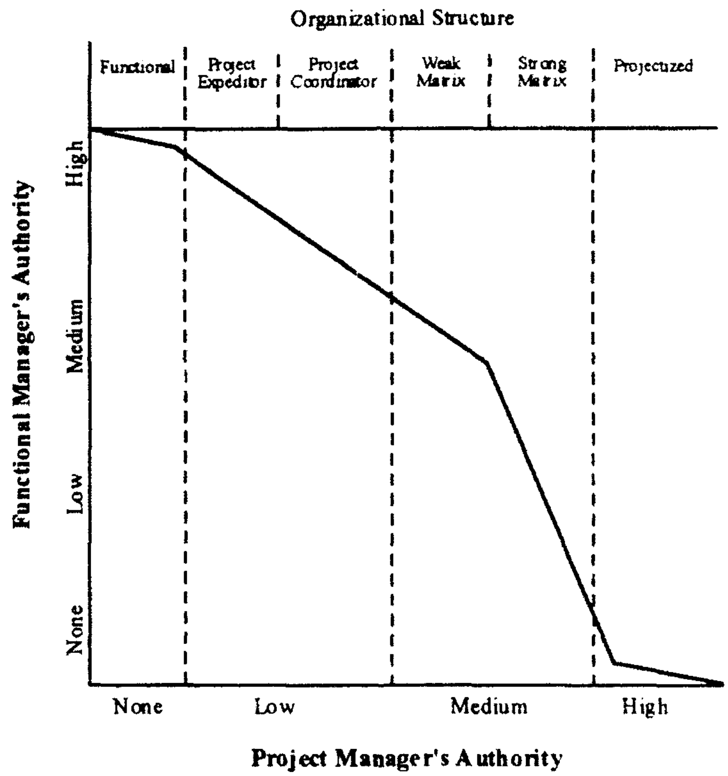

Figure 8.1. Organization/Authority Continuum

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[5]Dwayne Cable and John R. Adams, Organizing for Project Management, (Drexel Hill, PA: Project Management Institute, 1989) 23-24.

[6]Ibid., adapted from the figures on pages 2 and 24.

The figure shows an organizational continuum with the strong matrix and projectized forms of organization illustrated on the right hand side of the figure where the relative level of authority favors project managers over functional managers. In the companies studied, this relationship was confirmed even though structure of each project is somewhat different. The relative amount of authority each project manager exercises varies between companies and among projects within each company. In addition, each project manager's authority varies relative to different functions in the organization. In the case of the environmental managers, the difference in authority is relatively large. At each company studied, the environmental management function is headed by a mid-level manager that does not have day-to-day access to the top executives. The project managers, on the other hand, are senior managers with regular access to the executive level.

While the project managers have greater authority, there is still a complementary relationship between project organizations and functional organizations in terms of responsibilities. These complementary responsibilities between project and functional managers are described by Cleland and King[7] and are summarized in Table 8.1.

Project Manager	**Functional Manager**
- *What* is to be done? - *When* will the task be done? - *Why* will the task be done? - *How much* money is available to do the task? - *How well* has the total project been done?	- *How* will the task be done? - *Where* will the task be done? - *Who* will do the task? - *How well* has the functional input been integrated into the project?

Table 8.1. Project-Functional Interface

In the acquisition program studied, project and functional responsibilities followed Cleland and King's findings closely. In addition, the responsibilities listed for the project

[7]David I. Cleland and William R. King, Systems Analysis and Project Management, (New York: McGraw-Hill, 1983), 350-351.

manager involve the same issues that the government is most concerned with: what is to be done, when, why, how much, and how well. These issues are also the subject areas for most of the recommendations that have come from this research.

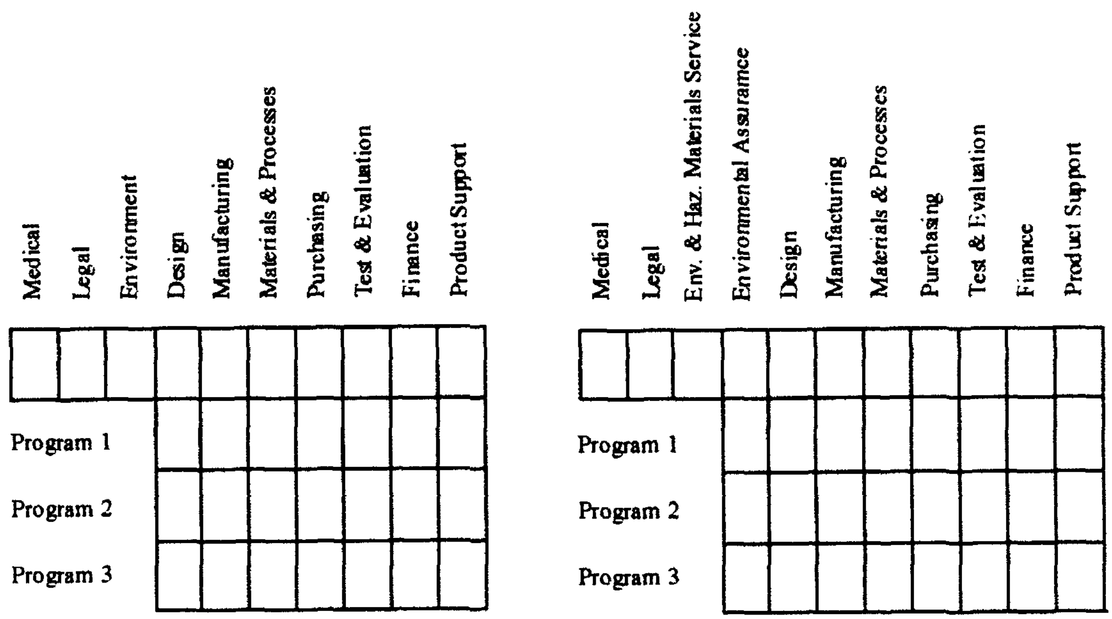
The functional responsibilities, which are listed on the right-hand side of the table, are usually considered to be a contractor's prerogative in acquisition programs. Of the four responsibilities listed, two were identified as implementation concerns in this research: 1) how will the task be done, and 2) how well has the functional input been integrated into the project. The first issue involves how life-cycle cost and cost-benefit analysis should be used. The second issue concerns integrating pollution prevention across functions and programs. Integration was found to be a problem in the each of the companies studied.

Figure 8.2 illustrates the organizational concept that MDA-E has adopted to deal with the integration problem. Traditionally, the environmental management function is one of organization's special functional staffs that serves the unit manager, but is not part of the matrix. At MDA-E, the special staff (Environmental & Hazardous Materials Services) has been supplemented with a new functional staff, Environmental Assurance, which is a part of the matrix. This is an important innovation. From the view point of a project manager, a primary purpose of functional organizations is to provide a pool of expertise that can be applied to the organization's projects.[8] In the past, environmental functions have not had a role in the project organizations. This is illustrated on the left-hand side of Figure 8.2 by the placement of the traditional environmental function outside the matrix organization.

In addition to providing skilled people to the project organizations, Cleland and King found that functional organizations also keep track of the functional state-of-the-art, provide a basis for professional association and career development, and provide a sense

[8]Ibid., 359.

of strategic direction for the disciplines within the function.[9] While Cleland and King did not specifically address environmental management in a matrix organization, this research shows that these roles also apply to the environmental function and are useful for understanding the problems being encountered in making the transition from special staffs to full functional staffs whose mission includes direct support to the programs. Making this transition has been difficult at each company.



Traditional Environmental Function   MDA-E Environmental Assurance Function

Figure 8.2. Environmental Management in the Organizational Matrix

MDA-E's approach, which created a new functional staff, was implemented by reallocating people from other functions. At P&W, responsibility for pollution prevention in new products was shifted from the environmental function to the materials and processes function (already a full functional staff). In both cases, these new organizational

[9]Ibid., 360-361.

structures are working to develop the supporting mechanisms that are needed to fulfill the functional roles described above.

At LASC, pollution prevention on the F-22 program is assigned to the system safety function. This arrangement is different from the situation at P&W because the workers assigned to accomplish pollution prevention do not look to system safety to provide functional support. Instead, the workers view the arrangement as an administrative convenience and they continue to look to their traditional functional areas for support. At LFWC, the traditional organizational structure is still in place and pollution prevention implementation and integration is being accomplished through the Hazardous Materials Management Program Office (which is similar to a pollution prevention working group).

Finally, in the companies studied, orchestrating change was viewed as an important functional role in implementing pollution prevention. This confirms Lawler and Galbraith's view that a functional staff's strategic role includes looking farther ahead than day-to-day line activity permits, determining the significance of coming events and technologies, and planning and orchestrating change.[10] Along with providing functional experts and services to the programs, orchestrating change can add value. The functional staff can help facilitate change by surveying best practices inside and outside the company, supporting demonstration projects, linking people with common interests, creating training materials, and keeping management informed of progress.[11] These activities are all being performed by the environmental staff at each of the companies studied.

8.4.2 Policy Implementation

The research design for this work was heavily influenced by the policy implementation literature. While most of the literature deals with implementation within

[10]Edward E. Lawler III and Jay R. Galbraith, "New Roles for the Staff: Strategic Support and Services," Organizing for the Future, Jay R. Galbraith, ed., (San Francisco: Jossey-Bass, 1993), 71-3.

[11]Ibid.

different governmental units, the methods developed were successfully employed here to study pollution prevention implementation in the aerospace industry and in aerospace system acquisition programs.

In reviewing the implementation literature Sabatier[12] concluded that there are four implications for understanding implementation in the public sector: 1) rather than start with a policy decision and then examine its implementation, it is usually preferable to begin with a policy problem and then examine the variety of actors actually and potentially involved in addressing it; 2) street-level implementators are always important to implementation, but the importance of official policy-makers varies; 3) in assessing the effectiveness of a program or policy, one needs to take into account a reasonably long time period, at least 5-10 years; and 4) the causal assumptions behind a program are a critical factor affecting performance and they are one of the factors most susceptible to policy learning.

This research supports these conclusions. First, the DoD pollution prevention policy for acquisition programs only addresses hazardous materials selection. If this policy decision had been used as the starting point for analysis, the research would have focused on the analysis of this policy which is contained in Section 7.4. This would have provided a very narrow understanding of how pollution prevention is being implemented in the aerospace industry. Instead, a policy problem[13] was selected for study which resulted in a much broader understanding of pollution prevention implementation.

Second, the implementators were found to be much more important to each company's pollution prevention efforts and successes than the corporate policy makers.

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[12]Paul A. Sabatier, "What Can We Learn from Implementation Research?" Guidance, Control, and Evaluation in the Public Sector: The Bielefeld Interdisciplinary Project, Franz-Xaver Kaufmann, Giandomenico Majone, and Vincent Ostrom, eds., (Berlin: Walter de Gruyter, 1986), 322.

[13]The policy problem from Section 4.1 states: Neither the Air Force nor the Department of Defense has instituted a comprehensive pollution-prevention policy framework that can be applied to system acquisition programs.

At all four companies, corporate and company policies play a minor role in pollution prevention outcomes.

Third, of the programs studied, only LFWC's has been active for more than five years. At MDA-E, the current program has been in place less than two years. Past implementation research has shown that this is too short a time period over which to expect results and to judge effectiveness. This proved to be the case at MDA-E. The company's toxic release inventory data has yet to show a significant difference as a result of their pollution prevention efforts and the workers' dispositions toward environmental issues were the least favorable among the four companies studied.

Finally, the causal assumptions incorporated into DoD's hazardous materials selection policy are called into question in this study. The policy assumes that pollution can be prevented by making rational, material-selection decisions during the design process based on life-cycle costs. LASC's experience on the F-22 program suggests that this assumption is only partially correct. The LASC Hazardous Material Review Board evaluates hazardous materials before they are specified and has had some success, but serious limitations in their process were also found. Based on the experience at LASC, the hazardous materials selection concept is limited by the amount of detailed information on manufacturing and maintenance and repair processes that is available at the stage in the design process when material selections are made. While LASC is not using the life-cycle cost methodology, this information limitation will similarly impact attempts to employ the life-cycle cost method. As a result of this limitation, this author recommends employing multiple pollution prevention concepts. The implications of several other pollution prevention concepts are explored in Section 5.3 on pollution prevention paradigms. Understanding the limitations of the hazardous material selection concept and the other concepts provides an opportunity for policy learning.

8.4.3 Defense Acquisition

Gregory[14] believes that the basic causes of the acquisition system's illness are the over specification, over regulation, and micromanagement that have resulted from the prescriptions of a regiment of doctors who set out to cure what was merely a nasty cold and in the process have created a procurement mess. In addressing the acquisition mess, the most commonly cited cure is for the government to scrap the existing system and to replace it with a new system based on the best practices used by large corporations when they undertake major development projects.

The Carnegie Commission on Science, Technology, and Government found that the problems with the defense acquisition system are rooted deeply in the regulation-based system of procurement with its insidious system of allowable overhead and that the critical ingredient for reform is adoption of commercial, market-based practices to replace the current regulation-based acquisition system.[15]

This author believes that the recommendations presented here are appropriate for improving pollution prevention implementation and are fully compatible with the cures being considered for the acquisition system. This view is supported by several considerations.

First, the recommendations do not define how to accomplish pollution prevention, as would be the case in a regulation-based system. Instead, the proposed set of pollution prevention criteria are aimed at establishing a management system that is goal-oriented. Indeed, the current technical documentation system that includes the military specifications, standards, and technical orders was found to be a significant obstacle to implementing pollution prevention.

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[14]William H. Gregory, The Defense Procurement Mess, (Lexington, MA: Lexington Books, 1989), 2-4.

[15]A Radical Reform of the Defense Acquisition System, William J. Perry, Chairman, (New York: Carnegie Commission on Science, Technology, and Government; Task Force on National Security, 1 December 1992), 1.

Second, the system of allowable overhead was also cited as a problem. Most of the pollution prevent efforts in the acquisition programs studied are being funded from overhead accounts. This is being caused by the reluctance of government program managers to directly fund environmental costs. This reluctance forces industry to respond using the only means available that allows it to recover these expenses.. This makes environmental costs difficult to manage and control on a program basis.

Finally, the recommendations address problems that must be corrected to effectively implement commercial pollution prevention management practices. The Business Roundtable[16] recently employed a benchmarking methodology to identify eighteen common elements that were found in successful pollution programs. The elements are shown in Table 8.2 matched with recommendations described earlier for integrating pollution prevention into the acquisition process.

The elements are categorized into three groups: Group A, initial elements used to set up the program; Group B, elements that helped to achieve best-in-class performance; and Group C, elements that sustain the program at a best-in-class level. Overall, the recommendations that result from this research address 16 of the 18 elements. Only elements 4 and 14 are not specifically addressed. Element 4 is already an integral part of the system engineering and design process. Element 14 is not an essential component for DoD policy, but is an excellent management tool as EPA's 33/50 Program demonstrates.

Beyond defense acquisition, the findings and recommendations are also useful to other agencies that are involved in large, high-technology projects such as the National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE). NASA's space shuttle program is a good example of a mature program like the F-15 and

[16]Randy S. Price, "Benchmarking Pollution Prevention: A Review of Best-In-Class Facility Programs," Pollution Prevention Review, (Winter 1993-94), 93-102.

F-16 programs studied here. The space station is still in development similar to the F-22. In addition, like DoD, NASA has a large number of smaller programs.

Group	Benchmarking Elements	Recommendations for Acquisition Process
A	1. Clear pollution prevention policy	Multiple changes needed to clarify DoD policy
A	2. Identify wastes and emissions	Identify requirements
A	3. Had pollution prevention goals	Identify goals
A	4. Have a champion or focal point person	Not specifically addressed, but included in the system engineering and design process of assigning responsibility for each requirement
A	5. Management support for pollution prevention	Demonstrated by adopting new policies
B	6. Integrated into business plans	Integrate into acquisition planning processes
B	7. Priorities assigned to waste streams	Identify values
B	8. Cross-functional teams used	Recommended pollution prevention principle
B	9. Cost-effectiveness a key criteria	Clarify decision criteria
B	10. Progress tracked	Monitoring criteria
B	11. Quality tools used in pollution prevention program	Recommended pollution prevention principle
B	12. Responsibility and accountability for results	Revise programmatic environmental assessment criteria
B	13. Programs patterned to company culture	Recommendations do not impose a regulation-based system that dictates how pollution prevention is to be accomplished
C	14. Recognition programs	Not addressed
C	15. Company resources support efforts	Government must directly fund efforts
C	16. Effective communication and awareness efforts	Provide opportunities for public comment
C	17. Integrated into pre-manufacturing decisions	Life-cycle design principle
C	18. Use new technology	Identify and evaluate technology

Table 8.2. Best-In-Class Pollution Prevention Factors

More broadly, the findings in this research on environmental impact analysis (EIA) are useful for helping all agencies understand the need to incorporate a micro-focused system of pollution prevention analysis into their environmental planning processes. While the activities of other agencies are significantly different from the activities of DoD and this may cause the implementation details to be different, all agencies can benefit from clearly specifying environmental values, setting goals, and measuring pollution prevention progress during the project development cycle.

8.5 Final Thoughts

This research began with the problem statement: neither the Air Force nor the Department of Defense has a comprehensive pollution prevention policy for systems acquisition. Since the research began, the Air Force has implemented programs for eliminating specific hazardous materials and for measuring progress in reducing the use of the materials included in EPA's 33/50 program, but neither the Air Force nor the Department of Defense has addressed the systemic deficiencies that must be corrected to implement an effective pollution prevention effort. The policy recommendations contained in this research provide a road map for resolving the systemic problems that are impacting pollution prevention implementation in system acquisition programs.

In studying these systemic problems, three pollution prevention paradigms were observed that have important consequences for implementing pollution prevention programs. As described in Chapter 5, the starting points for analysis, which are determined by the pollution prevention goals, are critical in each paradigm because they frame the problem to be solved. Understanding the pollution prevention paradigms illuminates the implementation implications associated with selecting different pollution prevention goals. This understanding can aid decision makers in selecting appropriate goals and in developing implementation strategies for individual programs.

Figure 5.21 illustrates the starting points for analysis of the three observed paradigms and shows three additional starting points for analysis that were not directly observed, but that are described in the design for environment and life-cycle assessment literatures. One avenue for future research would be to focus on better defining the characteristics of these other approaches to see if there is a more fundamental way to describe and categorize approaches to pollution prevention.

For example, in the F-22 program, LASC focused on design materials. In EPA's Energy Star Program, electrical equipment is be redesigned to reduce energy

consumption. In each of these efforts, the pollution prevention objective involves addressing a single environmental consideration during the design process.

Developing a recyclable telephone involves more than solving the technical material and processes issues associated with using recycled plastic. Marketing must be involved and so must the logistics staff that will have to collect and handle the returned phones. While materials and processes engineers play a major role in LASC's design-materials process, their role is much smaller when the objective shifts to energy efficiency. Designing an energy efficient computer monitor is primarily an electrical design task.

The examples all involve processes that are front-end oriented--that is the analysis is being conducted before the product is designed. In addition, the examples all involve a single design characteristic. It also appears that the more of the product life cycle that is considered in the design analysis the more difficult the problem becomes. Increasing the number of objectives also complicates the analysis.

In this framework, life-cycle analysis is a *methodology* that can be applied at either the front-end or the back-end, considers the entire product life cycle, and involves multiple objectives. Thus far, life-cycle analysis has been largely applied at the back-end. Conducting a life-cycle assessment of glass versus plastic soft drink containers or reusable versus disposal diapers involves applying the methodology from the back-end since the analysis started with well defined existing products. Applying the method at the front-end, before a product's design, distribution, and other factors are fixed, further increases the complexity of analysis.

In comparison to the level of complexity of conducting a forward life-cycle analysis, the observed pollution prevention efforts are modest, but as demonstrated here, the initial framing of the problem can have a broad set of implications that are not yet fully appreciated or understood. Understanding these implications would provide important information for setting policy, selecting goals, and designing programs for implementing pollution prevention.

APPENDIX A

AIR FORCE POLLUTION PREVENTION VALUES AND GOALS

The Air Force's pollution prevention values were identified in a series of four, one-hour interviews with Mr. Gary D. Vest, Deputy Assistant Secretary of the Air Force, Environment, Safety, and Occupational Health. The interviews took place between March and May 1992. Mr. Vest is a career civil servant and is the senior "environmental" official in the Air Force. His entire career has been in the environmental policy area. Thus, he represents an individual with decision responsibility, interest, and knowledge on pollution prevention.

A.1 Interview Process

The interviews were approached using the interview process described by Dillard and Reilly.[1] Their process involves four steps: 1) preparation, 2) initiation, 3) direction, and 4) conclusion. Prior to the initial interview, the interviewer developed a fifteen-minute opening briefing that explained the purpose of the interview and described the process that would be used to arrive at a final set of values. In addition, a sample decision problem was prepared to help focus the initial discussion. The sample problem tuned out to be an excellent vehicle. It allowed a series of open-ended questions such as, "What do you want to achieve in this situation, what is important, and what decision would you reach," to be used to begin the process of thinking about values.

Each interview was recorded to reduce the need to take notes during the discussion. Following each interview, a summary of the progress made in the prior interview was

[1]John M. Dillard and Robert R. Reilly, Systematic Interviewing: Communication Skills for Professional Effectiveness, (Columbus, OH: Merrill Publishing, 1988), 69-87.

prepared and key information put on overhead projector slides for easy viewing. Open-end discussion questions were also prepared for each subsequent session to guide discussion of the points needing clarification.

1st Interview	2nd Interview	3rd Interview	Final Interview
Support the mission	Support the mission	Support the mission	Support the mission
	Noncompliance is unacceptable	Comply with law and policy	Comply with law and policy
Minimize adverse impacts ――― Decrease adverse health effects	Minimize environmental releases and impacts ――― Reduce the use of and worker exposure to hazardous and toxic chemicals	Do the right thing - Minimize environmental releases and impacts - Reduce the use of and worker exposure to hazardous and toxic chemicals	Do the right thing - Minimize environmental releases and impacts - Reduce the use of and worker exposure to hazardous and toxic chemicals - Give priority to preventing problems
Stop compliance cost growth	Use tax dollars wisely	Make good business decisions - Cost is key, but use a life-cycle time perspective for long term acquisition decisions - Prevent future cleanup liabilities	Make good business decisions - Cost is key, but use a life-cycle time perspective for long term acquisition decisions - Prevent future cleanup liabilities
Improve operating efficiency	Reduce waste and inefficiency		Provide strong leadership and effective management
Enhance AF image	Act responsibly and openly with local communities and the public	Act responsibly and openly with local communities and the public	Act responsibly and openly with local communities and the public

Table A.1. Air Force Pollution Prevention Values

The number of interviews was initially left open. Mr. Vest agreed to continue until he was satisfied with the results. The key point in the process occurred late during the

first interview when Mr. Vest stated, "I find this very very useful. It is relevant to the kinds of decisions we face everyday. I want to take as much time as we need to think about this." On the basis of his stated desire to thoughtfully consider the values over a number of weeks and his continued high level of interest throughout the process, the final set of values is considered to represent the values the Air Force is trying to achieve in its pollution prevention efforts.

A.2 Pollution Prevention Values

During the first interview, six key values were identified. The evolution of initial six ideas to the final set of values is displayed in Table A.1. The values are listed in the order they were discussed in the final interview, but the list is unordered in the sense that none of the values is always more important than the others.

APPENDIX B

CASE STUDY AT LOCKHEED AERONAUTICAL SYSTEMS COMPANY

Marietta, Georgia

F-22 Advanced Tactical Fighter (ATF), C-130 Hercules

B.1 Introduction

Lockheed Aeronautical Systems Company (LASC), an operating company within the Aeronautical System Group of Lockheed Corporation, is major supplier of military aircraft and other systems. LASC's principle facilities at Marietta, Georgia are owned by the Air Force and operated by Lockheed. The government facilities are known as Air Force Plant 6 (AFP-6) and are situated on Dobbins AFB. The plant was constructed in 1943 and contains approximately eight million square feet of space.

In recent years, the C-130, C-141 and the C-5 military cargo aircraft and the Navy's P-3 maritime patrol aircraft have been assembled at AFP-6. Two of these aircraft, the P-3 and the C-130, achieved major production milestones in 1992. The P-3 entered its 30th year of production and the 2000th C-130 was delivered. In 1993, the C-130 began is 40th year of production, making it the longest-running continuous aircraft production program in aviation history. When the F-22 enters production, it will also be assembled at AFP-6.

B.? Case Study Organization

The remainder of the case study is organized into six major sections: 1) Program Overview, where general background information is provided for each program included in the study; 2) Corporate Background, where information on the parent corporation is presented; 3) Data Gathering, which provides information on how and when the study

data were collected; 4) Results and Analysis, where the details of the case are presented; 5) Summary; and 6) Text of Contract Pollution Prevention Requirements.

The heart of the case study, the Results and Analysis section, begins with a presentation of the relevant program contract requirements and corporate policies. The section continues with the organizational setting, features of the pollution prevention program, the corporate environmental record, and pollution prevention results. The final portion of section includes a separate analysis on each of seven different implementation factors.

B.3 Program Overview

This case study is primarily concerned with the F-22 that is under development. The C-130 program is used as a baseline for comparison with the F-22 program. The current status of both programs is summarized in Table B.1.

Program	Acquisition Phase	Contract Pollution Prevention Requirements
F-22	Engineering & Manufacturing Development	Extensive Hazardous Materials Program
C-130	Production	None

Table B.1. Program Status Summary

B.3.1 F-22 Advanced Tactical Fighter

The F-22 is being developed to be the Air Force's next-generation air-superiority fighter, a follow-on to the current F-15 fighter.[1] The aircraft is highly maneuverable at

[1]The F-22 is 62.5 feet long and has a wing span of 44.5 feet, approximately the same size as the F-15. Key design features of the F-22 include: using stealth, low-observable, technologies; supercruise (the ability to fly faster than mach one without afterburner); engine thrust vectoring; increased payload and range over the F-15; better maneuverability than the F-15, advanced integrated avionics capable of performing beyond-visual-range as well as close-in-combat missions, and internal carriage of weapons

both subsonic and supersonic speeds and it incorporates stealth technologies as well as a host of other technological advances in avionics, engines, and other systems.

In July 1991, the F-22 program was approved to begin Phase II, Engineering and Manufacturing Development (EMD), by the Defense Acquisition Board.[2] This decision led to an EMD contract in August 1991 valued at approximately $9.5 billion over a nine year performance period. The first EMD aircraft is currently scheduled to begin flight testing in 1996.[3]

Lockheed is the leader and system integrator of a corporate team designing and manufacturing the F-22. By agreement among the companies, the team divided the program into roughly thirds between Lockheed, Boeing, and General Dynamics.

In working to field this replacement for the F-15, the program manager believes that, "The Air Force confronts three severe challenges: keeping the fighter's weight down, giving it overwhelming power relative to its adversaries, and holding the line on costs."[4] Among these, cost is the greatest hurdle.

While weight is not a contract requirement in the F-22 EMD contract, it is important because it directly affects the performance of the aircraft and past experience has shown that greater weight usually equals greater cost. This is a significant issue in pollution prevention since the drive to control weight drives decisions to use newer, lighter, higher-strength, composite materials in place of traditional metal structures. While there is vast

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[2]Air Force requirements for the F-22 started to take form in about 1980. Concept definition contracts were awarded in 1984 and were followed by Demonstration/ Validation (Dem/Val), Phase I, contracts to two teams: Lockheed/Boeing/General Dynamics and Northrop/McDonnell Douglas. In April 1991, Phase I was completed with the selection of the Lockheed team by the Secretary of the Air Force as the winner of the prototype "fly-off" between the Lockheed/Boeing/ General Dynamics YF-22 and Northrop/McDonnell Douglas YF-23. At the same time, the Pratt & Whitney F119 engine was selected over General Electric's entry to power the F-22.

[3]The original EMD contract called for building thirteen aircraft, eleven for flight testing, and two for ground-based stress testing. The first flight test of an EMD aircraft was scheduled for 1995. Initial operational use of the aircraft was scheduled to begin in the early 2000s. Because of funding shortages, these dates have, and may continue to slip, and the number of aircraft is being reduced.

[4]Frank Oliveri, "The F-22's Triple Challenge," Air Force Magazine, (March 1993): 34-39.

experience with the traditional materials, much less known about the environmental impacts of using the newer materials and their associated manufacturing and maintenance processes.

During the Concept Definition and Demonstration/Validation phases of the program, there were no hazardous materials or other pollution prevention requirements in the contracts. Beginning with the EMD contract, the Lockheed team was tasked to initiate a Hazard Materials Program (HMP). The goals of the HMP are to eliminate the use of hazardous materials where possible and to mitigate the consequences of using hazardous materials as appropriate.

B.3.2 C-130 Hercules Cargo Aircraft

The prototype C-130 made its maiden flight on 23 August 1954 and after forty years, the C-130 Hercules transport is still in production. The Hercules is powered by four turboprop engines, making it one the few aircraft in the Air Force inventory not powered by jet engines. Over the years, the basic design has been continually updated. The newest version of the Hercules, the C-130J, is in final development and Lockheed plans to begin switching production from the H model to the J model over the next three to five years. Current C-130 production contracts have no hazardous materials or pollution prevention requirements.

B.4 Corporate Background

Lockheed Corporation had total sales of $10.1 billion in 1992, of which $3.0 billion came from its aeronautical business. This made the Aeronautical Systems Group the second largest in the corporation after the Missiles and Space Group with sales of $4.6 billion. The Technology Systems Group and the Electronic Systems Group each had sales of approximately $1.3 billion.

The Aeronautical Systems Group has undergone a number of changes in recent years. Under a plan initiated in 1989, aircraft manufacturing operations are being

consolidated into the Lockheed Aeronautical Systems Company's (LASC) facilities at Marietta, Georgia and the "Skunk Works" are being moved from Burbank, California to Palmdale, California. Following completion of the moves, the Burbank property is to be sold. Major programs at LASC include its one-third share of the F-22 fighter program, the C-130 transport, and the P-3 maritime patrol aircraft. Unclassified programs at Palmdale, now called the Lockheed Advanced Development Company (LADC), include upgrades to the Air Force's U-2 reconnaissance fleet and to the stealthy F-117A fighter-bomber.

In February 1993, Lockheed acquired General Dynamics Corporation's tactical military aircraft business in Fort Worth, Texas for approximated $1.5 billion. A new company, called Lockheed Fort Worth Company (LFWC), includes: General Dynamics' one-third share in the F-22 fighter program; the F-16 fighter program; the FS-X program, a joint venture between the United States and Japan to develop a F-16 derivative; and other smaller programs.

Year	Sales (billions)	Employees
1987	$11.079	97,200
1988	$10.433	85,600
1989	$9.891	82,500
1990	$9.958	73,000
1991	$9.809	72,300
1992	$10.100	71,700

Table B.2. Lockheed Sales and Employment History

As with other aerospace companies and defense contractors, Lockheed has both restructured and reduced the size of its work force over the past several years. As shown in Table B.2,[5] Lockheed has cut employment by 26 percent in the last five years. As of

[5]G. D. Shapiro, "U.S. Aerospace/Defense Electronics: 1Q 1993 - Industry Report." (New York, NY: Salomon Brothers Inc., 13 May 1993).

December 1992, LASC employed approximately 11,000 people or about 15 percent of Lockheed's total.

B.5 Data Gathering

Data on LASC was gathered during a visit to the Marietta plant from 13 to 17 September, 1993. During the week, fifteen people were interviewed, the LASC environmental staff presented briefings, production operations were observed, and 64 questionnaires were completed by LASC personnel.

Background information was collected during a prior site visit that occurred on 21 July 1993. Both visits were sponsored by the Air Force's F-22 program office.

B.6 Results and Analysis

B.6.1 Policy Framework

B.6.1.1 Corporate Environmental and Pollution Prevention Policies

At the corporate level, Lockheed's Corporation Management Policy Statement (CMPS-173), "Environmental, Safety, and Health Protection" covers basic compliance responsibilities. The corporation has no written policies on hazardous materials or pollution prevention; however, Lockheed has volunteered to meet the chemical release reduction goals in EPA's 33/50 Program. LASC, along with the other operating companies, participate in the program. Overall, the corporation has delegated most environmental policy issues to its operating companies.

At the operating company level, LASC's key pollution prevention policies are contained in two LASC Management Directives: A-60, "Environmental Protection" and S-19, "Hazardous Materials Review Board."[6]

[6]Related documents include: Management Policy Statement No. 169, Occupational Safety and Health; Management Policy Statement No. 173, Environmental Protection; Corporate Operations Directive 17, Environmental Manual; Management Directive A-6, Disaster Prevention and Recovery;

According to Management Directive A-60, "Environmental Protection", LASC's core environmental policy document, pollution prevention is identified as a key part the company's environmental management philosophy:

> Objective: To assure that all Lockheed Aeronautical Systems Company (LASC) operations are conducted in compliance with the applicable environmental laws and regulations.
> Policy: To be a good environmental neighbor by controlling operations in a manner that eliminates or minimizes adverse effects on the environment while complying with the applicable laws and rules. . .
> Pollution Prevention: It is the policy of LASC to have a pollution prevention program for the minimization of hazardous wastes. Hazardous waste minimization involves volume or toxicity reduction through either a source reduction or recycling technique and results in the reduction of risks to human health and the environment. The pollution prevention program results in reduced costs and future liability, and ensures regulatory compliance. A Pollution Prevention Plan is maintained by the LASC Environmental Coordinator and provides documentation of the program activities and accomplishments.[7]

The Minnesota Guide to Pollution Prevention Planning, written by Terry Foecke, a leader in developing pollution prevention implementing strategies, states that a pollution prevention policy statement should provide a clear understanding of, 1) why a pollution prevention program is being implemented, 2) what will be done, and 3) who will do it.[8]

LASC Management Directive A-60 meets all three of Foecke's criteria for a hazardous waste minimization program. First, the program is being implemented to reduce costs and future liability. Second, the purpose of the pollution prevention program is to minimize hazardous waste, and third, the policy tasks the Environmental Coordinator to maintain a Pollution Prevention Plan. Thus, the policy meets the criteria, but only for a very limited subset of possible pollution prevention objectives.

Management Directive A-57, Safety Program; Management Directive A-59, Occupational Safety and Health; and Management Directive S-12, Control of Hazardous Materials.

[7]Lockheed Aeronautical Systems Company, "Environmental Protection," Management Directive A-60, (Marietta, GA: Lockheed Aeronautical Systems Company, 29 June 1991), 1-2.

[8]Terry Foecke and Al Innes, Minnesota Guide to Pollution Prevention Planning, (St. Paul, MN: Minnesota Office of Waste Management, 1992) 2-1.

The policy does not address the product life cycle. It appears to focus on manufacturing. This seems to minimize the role of the engineering design and product support functions. It does not task line managers. Instead, responsibility is an environmental function. Finally, it is too specifically focused on hazardous waste minimization. As written, the policy would seem to have little application to a new system other than hazardous waste minimization during production.

Although Management Direction A-60 could be improved, it is not the only policy that addresses pollution prevention. Policies on the acquisition, movement, storage, and disposal of hazardous materials are contained in Management Directives S-12, "Control of Hazardous Materials" and S-19, "Hazardous Materials Review Board." Management Directive S-12 covers day-to-day operating procedures and Management Directive S-19 establishes a Hazardous Materials Review Board (HMRB).

The HMRB is, "Responsible for reviewing all hazardous materials currently located and/or in use at LASC and for approving the first-time acquisition of all hazardous materials in the future."[9] Reviews for new materials must be conducted prior to the hazardous material being brought onto LASC property. Management Directive S-19 establishes the HMRB's responsibilities and membership, and the operating procedures for submitting materials for HMRB review.

B.6.1.2 Government Pollution Prevention Requirements

The F-22 EMD contract requires the Lockheed team to conduct a hazardous materials program (HMP) as described in section 3.4.1.10 of the contract statement of work (SOW).[10] In response to the SOW requirements, Lockheed developed and

[9]Lockheed Aeronautical Systems Company, "Hazardous Materials Review Board," Management Directive S-19, (Marietta, GA: Lockheed Aeronautical Systems Company, 30 November 1991), 1.

[10]Lockheed Aeronautical Systems Company, "F-22 FSD Statement of Work," Section J, Attachment 1 to Contract Number F33657-91-C-0006, submitted to USAF Aeronautical Systems Division, (Marietta, GA: Lockheed Aeronautical Systems Company, 7 March 1991), 33-34.

submitted to the Air Force a Hazardous Materials Program Plan (HMPP) that describes how the F-22 team companies intend to meet the contract requirements. The complete text of the section is provided at the end of the case study in section B.7. A summary of the contract pollution prevention requirements is provided in Table B.3.

Program	Contract Requirements
F-22	- Identify and control hazardous materials --Develop and implement a Hazardous Material Program Plan --Submit data on hazardous materials to the Government --Record decisions on hazardous material uses
C-130	- None

Table B.3. Summary of Pollution Prevention Contract Requirements

According to the HMPP, the objective of the F-22 Hazardous Materials Program (HMP) is to:

> Ensure that hazardous material (HM) environmental, health and safety concerns are identified and controlled during EMD by the F-22 team (Lockheed, Boeing, General Dynamics), including its associate and subcontractors, in the design, manufacture, operation, repair, maintenance, support, and disposal phases over the weapon system life cycle.[11]

In addition to the HMPP, the contract requires the contractor's to submit a Weapon System Hazardous Material Analysis Report (WSHMAR). The WSHMAR contains a Hazardous Materials Data Base, consisting of the information required by Data Item Description OT-90-34208,[12] and Material Hazard Action Records (MHARs).[13]

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[11]Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," (Wright-Patterson AFB, OH: Aeronautical Systems Center, 6 March 1992), 2-2, CDRL A001, DI-OT-90-34206, WBS 41A0.

[12]Data Item Description OT-90-34208 requires the following information for each hazardous material:

1. Hazardous material or waste name
2. Usage
3. Material Safety Data Sheet (MSDS) numbers
4. Material Specification numbers
5. Chemical components
6. Quantity uses

The SOW requirements for the HMP were structured by the program office with help from the staff of the Aeronautical Systems Center (ASC), System Safety Office. The staff had access to the Pollution Prevention Act of 1990, DoD Directive 4210.15, "Hazardous Materials Pollution Prevention," and to draft copies of Air Force pollution prevention policies. Within this general framework, the ASC staff developed a draft statement of work and the data item descriptions (DIDs). The key staff consisted of system safety and bioenvironmental engineers.

Prior to the final selection of the Lockheed team, the Air Force's Advanced Tactical Fighter Program Office hosted an initial meeting of an Environmental and Hazardous Materials Control Working Group on 17 October 1990. At the meeting, the Air Force's plans for including hazardous materials management in the Request for Proposal (RFP) for the Engineering and Manufacturing Development (EMD) phase of the program were presented to the competing airframe teams and to the engine contractors. At the meeting, different approaches to hazardous materials management were discussed:

> Too often an approach is used which compares lists of all regulated chemicals with lists of all materials associated with the system. Usually, this method results in unmanageably large numbers of potential hazards. . . In addition, significant health hazards can be overlooked if the material in question has not yet been identified as a regulated chemical. In contrast to the list-based approach, health and environmental professionals typically use a process-base approach. This process involves determining what major processes are performed, what materials are used in large quantities, and what wastes present disposal problems. . . This

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7. Hazards of material to personnel or environment
8. Expected exposure levels and established exposure limits
9. Maintenance and repair procedures and their related exposure limits
10. Recommended safety and handling procedures, including personnel protective equipment
11. Requirements for transportation or material
12. Requirements for storage of material
13. Recommended disposal procedures

[13]MHARs are to be prepared for material hazards that are significant enough to require special management attention. The MHAR describes the material hazard, the operation or conditions when the hazards can or does occur, the control measures implemented to control the hazard, and a chronological event log or the actions taken to control the hazard, analysis performed, review, and risk acceptance by the System Program Office (SPO).

process-based approach makes it possible to focus limited resources on the most important hazardous materials issues first.[14]

Following the meeting, the proposed HMP requirements were accepted by the program manager and were included in the final RFP that was provided to the contractors on 1 November 1990. The contracting procedures used allowed the contractor's to write their own final statement of work (SOW), but each team had to include the same Data Item Descriptions (DIDs). The DIDs contain information on the content and format for information that must be submitted to the Government. The RFP included two hazardous material DIDs, one requiring a hazardous materials program plan, and the other requiring a weapons system hazardous materials analysis report. Thus, the SOWs submitted by each team differed, but each SOW included the DIDs.

B.6.2 Organizational Setting and Scope of Pollution Prevention Activities

B.6.2.1 Organizational Setting

LASC is organized along product and functional lines. Figure B.1 shows a partial organizational chart for LASC and includes subdivisions important to the company's F-22 and overall pollution prevention efforts. In addition to the vice presidents shown, there are also vice presidents for Finance and for Human Resources, as well for the other major programs.

According to Mr. Blackwell, LASC President, the current organizational structure was designed by LASC's Lean Enterprise team with four principal objectives:

1. Organize all company functions by lines of business (LOBs) through projectizing
2. Implement integrated product teams (IPTs) throughout the company.
3. Organize around processes.

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[14]Lt. Col. Harvey Clewell, remarks recorded in the, Advanced Tactical Fighter (ATF) Environmental and Hazardous Materials Control (EHMC) Working Group (EWG) Minutes, meeting held at Wright-Patterson AFB, OH, 17 October 1990, (Wright-Patterson AFB, OH: ASD/YFMG, 27 November 1990) 2.

4. Reduce the layers of management and optimize the span of control by increasing the number of employees assigned to each manager.[15]

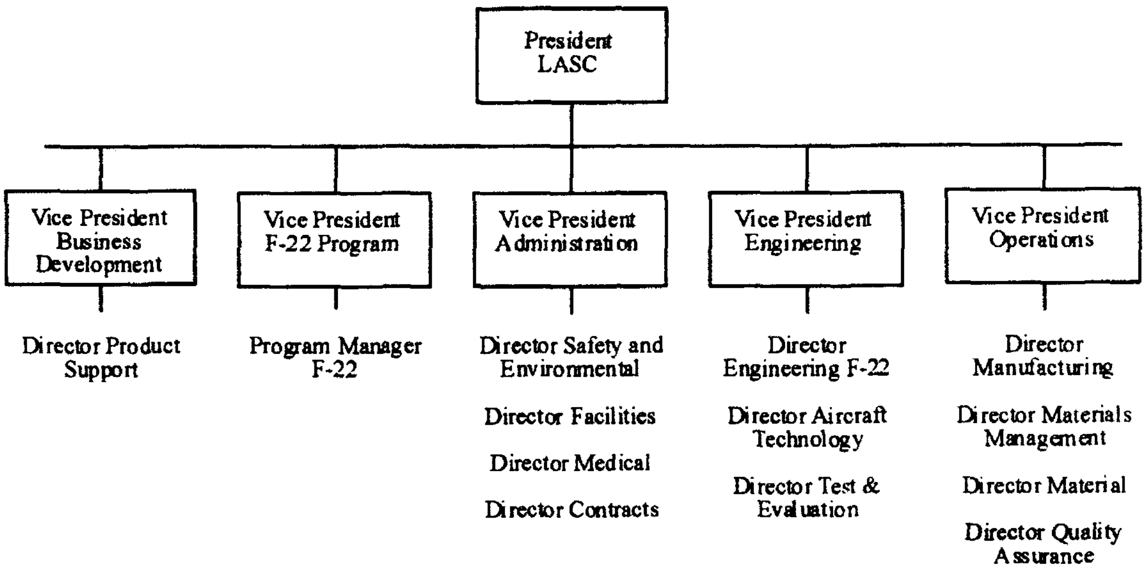

Figure B.1. LASC Organizational Structure

As a result of the recent reorganization, "all engineers who work full time on the F-22 now report directly to the Director of F-22 Engineering."[16] Within projects, however, the organization continues to be structured along traditional functional lines. For example, there are eleven chief engineers working for the Director of F-22 Engineering. The list of chief engineers includes structures; vehicle integration and integrity; flight sciences; weight control; airframe & systems design; configuration, analysis and integration; avionics; flight test; system engineering; computer resources; and systems technology.

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[15]Micky Blackwell, "Lean Enterprise focuses on re-engineering LASC organizations," Star, Lockheed Aeronautical Systems Company, 6 August 1993, 2.

[16]Ibid.

B.6.2.2 Pollution Prevention Program Scope and Key Features

The pollution prevention program at LASC consists of two major thrusts: 1) improving hazardous materials management, and 2) reducing the use of hazardous materials and the release of wastes. The first thrust, hazardous materials management, includes three major goals:

1. Creating a Hazardous Materials Review Board (HMRB),
2. Controlling the acquisition, movement, storage, and disposal of hazardous materials,
3. Improving the management and flow of information on hazardous materials.

The Hazardous Materials Review Board (HMRB) was created to help LASC comply with acquisition, inventory, safety, transportation, and disposal requirements for hazardous materials. To accomplish this, the HMRB is tasked to, "Administer a program by which hazardous materials used by LASC are reviewed, classified, and approved prior to acquisition."[17] In addition to reviewing and approving which hazardous materials can be used at LASC, the HMRB also defines hazardous material use and management parameters. Use parameters include items such as personal protection equipment, ventilation, and monitoring. Management parameters include pollution prevention considerations such as elimination, substitution, and consolidation as well as waste management and disposal.

Responsibility for initiating a hazardous material review rests with the design or operations engineer that plans to specify the material. Once an engineer decides to propose a new material, the engineer starts the HMRB review process by completing a detailed, three-page, hazardous material submittal form. The form lists the requester, a description the material including what material if any the new material will replace, a description of what the material will be used for, quantities needed, processes involved, etc. Using this information and a material safety data sheet, the HMRB rates each

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[17]Lockheed Aeronautical Systems Company, "Hazardous Materials Review Board," 1.

material using a scoring model. An outline of the model's current components is shown in Table B.4.

Each section of the model is scored by the appropriate LASC technical staff. The model is used to summarize the degree of hazard the material presents. This allows the HMRB to ensure an appropriate match between hazard and controls for each material.

When approving a material for use, the HMRB issues specific instructions that define personal protective equipment, ventilation, disposal, and user guidance requirements for the specific application. Since each approval is specific for the specified process and location, each different use of a material must be approved.

CATEGORY	SCALE
Health	
Personal Protective Equipment	0 to 3
Ventilation	0 to 3
Toxicology	0 to 10
Fire Protection	
Health	0 to 4
Flammability	0 to 4
Reactivity	0 to 4
Special Restrictions	0 or 4
Quantity Restrictions	
Volatile Organic Compound	0 or 4
Hazardous Air Pollutant	0 or 4
Ozone Depleting	0 or 4
Toxic Substances Control Act	0 or 4
Monitoring	
Industrial Hygiene	0 to 3
Medical	0 to 10
Disposal	0 to 3
Reporting	
Toxic Release Inventory	0, 4, or 8
Hazardous Waste	0 or 4
Toxic Substances Control Act	0 or 4

Table B.4. Hazardous Material Scoring Model

Within the HMRB, the major technical organizations with responsibilities for hazardous materials are represented. This is a significant factor in allowing the HMRB to

function as a "materials" integrated product team (IPT) with the goal of reaching balanced decisions on material uses. Table B.5 lists the membership of the HMRB.

When the HMRB was established, F-22 materials were received the highest priority for review. In addition, priority was also given to materials proposed for other systems that were not already in use at LASC. Review of materials already in use was to follow when the HMRB work load permitted. After two years, the review of LASC's existing materials is now underway.

Director of Safety and Environmental, Chairperson
F-22 Hazardous Materials Program Manager
Safety Operations
Environmental
Hazardous Materials Control
Industrial Hygiene
Fire Protection
Materials and Process Engineering
Material Science and Testing
Medical Director
Facilities Operations
Buildings and Utilities Maintenance
Operations
Environmental Compliance
Material
Legal

Table B.5. Hazardous Material Review Board Membership

LASC's HMRB is unique among the companies visited. It is well organized, operates efficiently, and includes mid-level managers as the decision makers. The HMRB operates formally and engineers proposing hazardous materials are often asks to "defend" the merits of their selection. It is this "defense" step before middle management that separates this process from the processes at the other companies. The other companies each have, or are working to establish, a review procedure for controlling the first time purchase of new materials, but the processes tend to be paper coordination procedures. The strength of the HMRB is that the proposer is forced to consider the company's pollution prevention policy, look at alternatives, and convince the HMRB that approving

the material is the "best" solution. This puts the principle burden on the designer to demonstrate that the material should be approved, rather than on the environmental, health, and safety staffs to prove that a material should be rejected. This changes the organizational dynamic and the organizational culture on pollution prevention.

The second major goal of LASC's hazardous materials management efforts involves controlling the acquisition, movement, storage, and disposal of hazardous materials. This effort, as well as the next goal concerning information, is driven by Lockheed's desire to avoid a repeat of the OSHA fine levied on the Burbank plant.[18] To LASC's credit, they examined what changes were needed, developed an implementation plan, and are investing time, money, and manpower to make major changes in the way hazardous materials are managed.

The most import aspect of the changes was getting control over who could order what materials. The HMRB contributes to answering what can be ordered. Controlling the purchasing of hazardous materials required discipline in the various purchasing systems.

Another key element in LASC's plan was the creation of a Hazardous Materials Handling and Control section with responsibility for controlling and tracking all hazardous materials from purchase through disposal. The section is within the operations organization. Setting up the section required facility modifications, new equipment, computer support, and manpower. Important improvements introduced by the section include centralized receipt and storage, bar coding and dispensing, same day issue and return of materials, a tracking data base, and responsibility for disposal of unneeded materials and expired shelf life materials.

[18]See section D.6.2.3 "Corporate Record on Environmental Issues." for a discussion of an OSHA $1.5 million fine at the Burbank plant.

A third goal in improving hazardous materials management at LASC involves improving the management and distribution of information on hazardous materials. The core of this effort is managing material safety data sheets (MSDSs).

Before the effort began, LASC had 2000 MSDSs on hand. Paper copies were hard to control and maintaining up-to-date information in the work places was impossible. LASC now has over 14,000 MSDSs entered into an electronic data base and are actively working to obtain MSDSs on several thousand more materials for which they do not have a current MSDS. The electronic system consists of a scanned copy of the original that can be called up and viewed as well as key information taken from each MSDS that can be searched and sorted. The system is designed to allow any worker to use any computer terminal in the work place to access any MSDS. This will eliminate the need to maintain paper copies of MSDSs in the shops.

In addition to its major thrust on hazardous materials management, LASC is also actively pursuing pollution prevention in its manufacturing operations. This major thrust includes initiatives in five major areas:

1. EPA 33/50 Program chemicals
2. Volatile Organic Chemicals (VOCs)
3. Hazardous Waste
4. Wastewater
5. Recycling

Oversight of LASC's efforts in these areas is being consolidated in a newly formed Pollution Prevention Committee. Work on each issue is assigned to an integrated product team (IPT) formed specifically to resolve each problem. For example, within the EPA 33/50 Program chemicals, LASC has set an additional goal of eliminating all 1,1,1 trichloroethane (TCA) from LASC operations by April 1994. TCA is an ozone depleting chemical and is covered in the 1990 Clean Air Act Amendments that implement the Montreal Protocol.

Some of the actions required to eliminate TCA include finding replacements for the large quantities of TCA used in hand wipe and in fuel tank cleaning. In addition to their uses of "pure" TCA, they are working to identify and replace commercial products that contain TCA. To accomplish this, each task is assigned to a group of people with the needed qualifications.

To reduce plant-wide VOC emissions, a number of initiatives are underway. For example, high-VOC paints are being replaced with low-VOC paints; high efficiency painting equipment is being installed to reduce overspray and VOC emissions; degreasers are being upgraded to reduce evaporative losses; and high-VOC cleaners and solvents are being replaced with aqueous cleaning processes or with low-VOC cleaners.

Similar initiatives are underway in the other areas. From this discussion, it is clear that LASC's has an active program for preventing pollution and reducing wastes in its operations.

B.6.2.3 Corporate Record on Environmental Issues

In October 1988, Time reported that workers at Lockheed's Burbank plant filed a lawsuit complaining that an unknown toxic agent in stealth materials was causing, "a panoply of ailments--rashes, aches and pains, nausea, memory loss."[19] The Burbank plant involved housed the "Skunk Works" and was the production site of the F-117A stealth fighter. At the time, the F-117 program was still a "black" program. A black program is a program whose existence is classified.

The worker's complaints also touched off a lengthy inspection by the Occupational Safety and Health Administration (OSHA). In June 1989, OSHA announced a $1.5 million fine. Roughly half of the 440 citations alleged that Lockheed willfully mislabeled or failed to label chemicals and other materials. "OSHA also charged there was a

[19]Time, "In Sickness and in Stealth," 17 October 1988, 33.

purposeful lack of records about illness and injuries at the plant."[20] By June 1989, more than 200 workers had filed lawsuits or worker compensation claims.

By March 1989, the publicity (from Lockheed's perspective) became increasingly negative. The National Law Journal reported that:

> The miracle fiber and the wonder plastics may have something in common besides technological whizbangery.
>
> A case in the clerk's office of the suburban courthouse here has a familiar ring for those who watched asbestos litigation grow into a national monster. It complains of a boss conniving to run a poisoned work place, but this time with a nasty twist: What is being built on this assembly line is the top-secret Stealth bomber, and the defendants are wrapping themselves in the red, white, and blue of national security.[21]

The fine, lawsuits, and the resulting negative publicity served as a wake up call to Lockheed on hazardous materials. It was a turning point in both Lockheed's occupational safety and health program and its environmental program. In addition, while the incident took place in California, it helps explains LASC's approach to managing hazardous materials on the F-22--in particular, the formation, structure, and functioning of the Hazardous Materials Review Board as a management tool for integrating management concerns about worker health, safety, and the environment. This integration among the three functions is stronger at LASC than at the other three sites studied. At the other sites, occupational health, safety, and environment are combined in a single organization, but the three groups of professionals still function very independently from each other.

Looking at LASC's compliance record, the facility has done very well in most of its compliance inspections. In 1992, LASC was inspected ten times by outside environmental, health, and safety regulators. Through July of 1993, ten additional inspections were conducted. The most serious violation resulted in a $75,000 fine by the

[20] National Law Journal, "OSHA Fines Lockheed on Secret Stealth Jet," 10 April 1989, 14.

[21] Gail Diane Cox, "Stealth's Other Secrets," National Law Journal, 6 March 1989, 1.

Environmental Protection Agency for open hazardous waste drums (the drum bungs were open). No instances of non-complying discharges were found.

A summary of LASC's TRI data from 1988 through 1992 is shown in Table B.6.[22] The figures shown represent total releases reported on the Form R. The figures do not include quantities used for energy recovery, quantities recycled, or quantities treated. Current EPA criteria require facilities that use more than 10,000 pounds of a TRI chemical per year to submit an EPA Form R on each chemical that exceeds the threshold.

Bold Chemicals are part of the EPA 33/50 Program
(All Figures are Total Chemical Releases in Pounds)

Chemical	1988	1989	1990	1991	1992
Acetone	0	0	0	50,000	0
Aluminum Oxide	0	0	0	63,000	42,000
Chlorine	20,000	20,000	20,000	22,000	22,000
Chromium Compounds	0	0	72,000	70,000	54,200
Hydrochloric Acid	0	0	0	9,000	0
Lead Compounds	0	0	3,400	3,000	0
Manganese Compounds	0	0	0	9,000	19,700
Methyl Ethyl Ketone	509,000	170,000	180,000	350,000	156,000
Methyl Isobutyl Ketone	36,000	7,000	22,000	6,000	4,600
Methylene Chloride	79,000	0	12,000	12,000	0
Perchloroethylene	242,800	7,000	0	0	0
Polychlorinated Biphenols	0	0	15,000	34,000	17,200
Sulfuric Acid	0	0	230,000	0	14,000
Toluene	437,000	85,000	118,000	33,000	14,000
1,1,1 Trichloroethane	823,000	250,000	290,000	960,000	152,900
Trichloroethyene	1,159,000	900,000	1,206,000	50,000	485,000
Xylene	378,000	7,000	8,000	7,000	3,800
Zinc Compounds	0	0	36,000	35,000	35,400
33/50 Program Releases	3,663,800	1,426,000	1,911,400	1,491,000	870,500
Total TRI Releases	3,683,800	1,446,000	2,212,400	1,713,000	1,020,800

Table B.6. LASC Toxic Release Inventory (TRI) Reporting
From 1988 through 1992

[22]Lockheed Aeronautical System Company, "TRI Chemical Reporting From 1988 Through 1992," company report, (Marietta, GA: Lockheed Aeronautical Systems Company, 31 January 1994) 1-2.

LASC's 1988 TRI baseline is 3,683,800 pounds of chemical releases. For the most recent year available, 1992, Lockheed reported total releases of 1,020,800 pounds. This represent a reduction of 72 percent from the 1988 baseline.

The data shown in Table B.6, which was supplied by LASC, does agree with information taken from the EPA's TRI data base, the Toxic Chemical Release Inventory System (TRIS). In January 1992, an EPA report titled, "Toxic Release Inventory Report for Government-Owned, Contractor-Operated Federal Facilities," was prepared by the Office of Federal Facilities Enforcement using the TRIS data base. The report lists total releases for LASC in 1988 as 2,585,885 pounds.[23] The report also indicates that LASC did not submit any TRI data for 1989.

Mr. Steelman, at LASC, states that the figures shown in Table B.6 come directly from LASC's copies of the Form R reports submitted to EPA.[24] The most logical explanation for the variance is that EPA incorrectly entered the 1988 data and has either lost the 1989 data, or incorrectly entered the facility identification information.

LASC, along with the rest of Lockheed, is a voluntary participant in the EPA's 33/50 Program, which calls for reduction of the releases in seventeen chemicals by 33 percent by 1993, and 50 percent by 1995 based on a 1988 baseline. LASC's 1988 baseline for EPA's 33/50 Program is 3,663,800 pounds. For 1992, LASC reported 33/50 Program releases of 870,500 pounds. This is a 76 percent reduction compared to the goal of reducing releases of the program specific chemicals by 50 percent by 1995. LASC has extended the effort by establishing an internal goal for an 80% reduction by 1997. As of 1992, LASC is only four percent short of reaching its 80 percent goal.

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[23]Office of Federal Facilities Enforcement, Office of Pollution Prevention, "Toxic Release Inventory Report for Government-Owned, Contractor-Operated Federal Facilities." (Washington D.C.: US Environmental Protection Agency, January 1992).

[24]Ken Steelman, Lockheed Aeronautical Systems Company, telephone conversation with author, 31 January 1994.

The greatest portion of the reduction can be attributed to LASC's successful solvent use reduction efforts. For example, trichloroethylene and 1,1,1 trichloroethane were used for cleaning many aircraft components; however, aqueous cleaners are replacing these solvents for many metal cleaning operations. In addition, methyl ethyl ketone and methyl isobutyl ketone were used as wipe solvents. Now, they are being replaced with non-chlorinated, low toxicity solvents.

Most of LASC's TRI data is derived from purchase records for Engineering Performance Specification (EPS) materials.[25] EPS materials include all materials that are used in direct production. While these materials are bought using detailed performance specifications, LASC has only been able to track releases from "pure" products. Thus, through its 1992 TRI reports, emissions from compounds that contain TRI reportable components have not been reported. This situation is changing, however, as the coverage in the new MSDS data base becomes more complete. In the future, LASC will be able to estimate all emissions. Other materials, such as those used in facility maintenance, are not part of the EPS system and in the past, the data on the quantities of these materials being used was less reliable. Again, this is changing as all hazardous material control functions are transferred to the new Hazardous Materials Handling and Control section.

B.6.2.4 Implementation and Results

B.6.2.4.1 F-22 Program

The hazardous materials management process used on the F-22 is described in the Hazardous Materials Program Plan (HMPP). The program includes identification,

[25]Like at other facilities, much of LASC's TRI data is estimated using a mass balance methodology. For example, since solvents do not become part of a product, the total annual purchase is assumed to be released. Quantities for the amount recycled and the amount disposed as hazardous waste are known. The unknown quantity is the amount released to the air. This quantity is estimated by subtracting the hazardous waste and the amount recycled from the annual purchase amount. The difference is assume to be the release to the air.

evaluation, elimination, minimization, and mitigation tasks. The HMPP states that it covers system design, manufacturing, operation, repair, maintenance, support, and disposal decisions affecting the Air Force.[26] System design and manufacturing issues having no impact on the Air Force are addressed by company internal policies and applicable federal, state, and local regulations.

The HMPP calls for the F-22 contractors to identify all hazardous materials considered for use on the weapon system. The evaluation task includes identification and assessment of the environmental, health, and safety requirements, including applicable standards, transportation, storage, uses of hazardous materials, disposal of hazardous wastes, and mishap procedure requirements. The plan states that hazardous materials and processes will be eliminated or minimized where practical from the air vehicle, training system, and support system. If hazardous materials cannot be eliminated, by design or substitution, they are to be mitigated as judged appropriate by the Integrated Product Team (IPT).

The HMPP's objectives, as described above, are very comprehensive. While LASC has accomplished a lot, the F-22 program has not accomplished all of the HMPP objectives.

The primary methodology for accomplishing the HMPP objectives is hazardous material process shown in Figure B.2.[27] The process, called the identification-evaluation process in this paper, is named after its first two steps. It is a procedural process in that success is defined in terms of completing the series of management steps that follow identification.

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[26]Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," 2-2.

[27]Arline Denny, "F-22 Hazardous Materials Program," presentation made at the <u>8th Annual Aerospace Material Management Conference, Chandler, AZ, 26-28 October 1993</u>. (Marietta, GA: Lockheed Aeronautical Systems Company, 1993), 7.

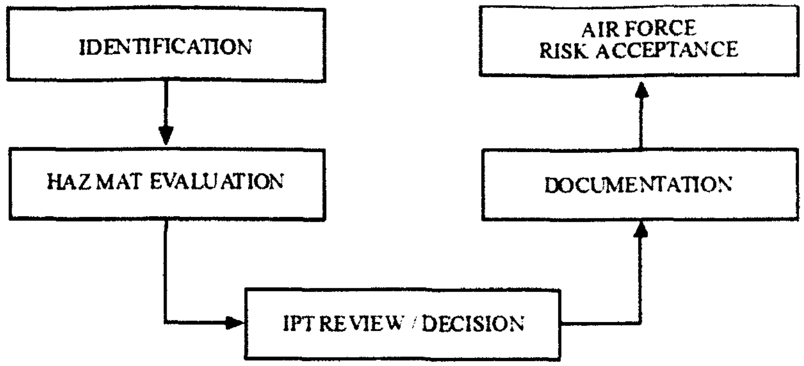

Figure B.2. Identification-Evaluation Process

The strength or weakness of this process rests on the criteria used in the evaluation step and on the requirements that frame the decision process in the third step. At LASC, the evaluation step occurs in the Hazardous Materials Review Board (HMRB). The evaluation process is professionally handled and, as the scoring model indicates, relatively comprehensive. The HMRB process is a yes-or-no screen that has rejected one or two percent of the "worst" materials originally proposed for the F-22. This is a notable accomplishment and shows that the IPT process is working as it should. If the HMRB rejects too many materials, it would indicate that environmental issues are not being considered in the design process. Conversely, if the HMRB never rejects any materials, there would be no need for the HMRB.

In addition, the guidance from the HMRB on personnel protection, ventilation, disposal, etc., greatly enhances LASC's ability to meet occupational health, safety, and environmental compliance requirements. The guidance does not address ways to minimize usage, releases, or impacts of the approved materials. In short, it is an important first step in the pollution prevention process, but only the first step.

Following HMRB review, 98 percent of the hazardous materials reviewed are approved for use on the F-22. Lockheed's Hazardous Materials Program Plan (HMPP), calls for a process-oriented approach for managing the hazardous materials that pass the

initial HMRB screen. The criteria for establishing a process-oriented approach are spelled out in the prioritization factors found in the HMPP and includes five factors:

- Materials not common to standard aerospace manufacturing,
- Chemical production and use reduction goals established by regulation,
- Large quantity use,
- Severe use restrictions by environment, health and safety regulations, or
- Materials having significant hazardous material life cycle cost requirements.[28]

While the HMPP proposed this prioritization scheme, it has not been actively used because the Air Force provided LASC with a priority list. What is to be done once the materials are prioritized is not described in the HMPP, but LASC has taken a number of actions.

First, they identified processes, specifications, and uses of the materials on the Air Force's priority list. Beyond this, they identified processes and specifications likely to contain hazardous materials that would be used during operation, maintenance, and repair. These include materials such as adhesives, paints and coatings, sealants, cleaners, and lubricants and oils as well as processes such as plating, anodizing, conversion coating, etc. Examining these materials, the F-22 team has identified a number of readily available substitutes.

In addition, LASC has been working with the staff at the Air Force's primary depot for the F-22, McClellan AFB, California to define acceptable repair processes and materials. This is a good initiative in that LASC engineers in Georgia get input on compliance issues in California.

By looking at processes and materials known to cause environmental impacts during operations and maintenance, LASC has broadened the scope of the identification step in the identification-evaluation process. Now, instead of only reviewing hazardous materials proposed by the design engineers, the LASC staff is in a position to explore alternatives

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[28]Ibid., 2-3.

and issue design guidance before hardware is designed, and maintenance procedures and technical manuals developed. This addition to the process is shown in Figure B.3.

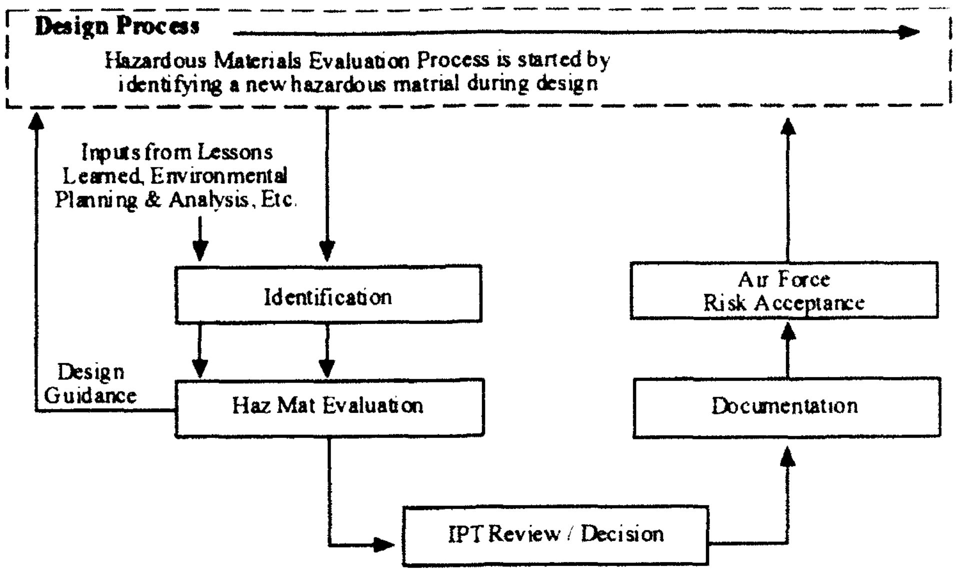

Figure B.3. Revised Identification-Evaluation Process

Although this greatly improves the process, a comprehensive and systematic process for carrying out the HMPP's pollution prevention objectives that concern operation, repair, maintenance, and disposal of the system is still needed.

B.6.2.4.2 Environmental Metrics

LASC's pollution prevention program covers five major areas. The five areas along with the metrics used to measure progress are shown in Table B.7. The metrics are appropriate for LASC's goals. The only negative aspect of LASC's metrics is that they all address pollution prevention on a facility-basis. The metrics provide no insight into how the individual programs are performing or on how the programs are performing in comparison to each other. In addition, all of the facility-basis metrics measure facility-wide performance making it impossible for line managers to assess the progress of the various organizational elements.

#	Major Area	Metric
1.	EPA 33/50 Program chemicals	TRI reports & number of sources
2.	Volatile Organic Chemicals	TRI reports & number of sources
3.	Hazardous Waste	Hazardous waste manifests
4.	Wastewater	Flow meter records
5.	Recycling	Weight receipts

Table B.7. LASC Pollution Prevention Metrics

B.6.2.4.3 Management of Pollution Prevention Objectives

Management of LASC's facility-based pollution prevention objectives is being carried out by the Director of Safety and Environmental. Management of the hazardous materials management effort on the F-22 is being carried out within the program's management structure.

This results in an almost inevitable conflict between the functional staffs that feel left out decision making and program management's desire to work in integrated product teams where functional loyalties are subordinated to project loyalties. On the F-22, the Safety and Environmental staff have a minimal role, outside of the Hazardous Materials Review Board (HMRB). A large part of the problem is that the two efforts run into one another on the "factory floor." As LASC begins manufacturing aircraft parts for the engineering and manufacturing development (EMD) test program, the facility-based pollution prevention program's ability to reach its goals will become increasingly dependent on the success of the F-22's efforts. To improve the management of both efforts, closer coordination between core safety and environmental functions and program functions is needed.

One initiative to improve coordination is the development of a strategic plan for pollution prevention. At the time of the site visit, an environmentally-experienced, full-time, pollution prevention coordinator had just been selected and was scheduled to assume the pollution prevention duties the following week. The pollution prevention coordinator

will also chair the Pollution Prevention Committee. Integrating core functional capabilities and resources with program needs is a difficult task that has not been satisfactorily achieved at any of the companies visited.

B.6.2.4.4 Pollution Prevention and the National Environmental Policy Act (NEPA)

The F-22 program office completed an Environmental Assessment (EA) in April 1991 to support the DoD Milestone II decision to proceed to Engineering and Manufacturing Development (EMD). The main issues discussed in the EA were the impacts of the flight test program at Edwards, Holloman, Nellis, and Eglin AFBs. Manufacturing impacts on air and water quality were judged to be small. The EA also described the F-22's hazardous materials program for reducing hazardous material use. In addition, the EA contained a preliminary listing of hazardous materials that would be used in the system, but there was no indication of which materials would be used in the greatest quantities, which were the most toxic, or which would cause the greatest impacts. No specific data on manufacturing processes or pollution prevention options for reducing releases were presented.

While EMD EA met all requirements of the law, it could have done much more. It could have served as the planning vehicle for the Air Force to addressed strategic program-related pollution prevention goals and actions in a more specific and detailed manner. One way to do this would have been to examined the operational, maintenance, repair, and disposal releases and impacts from existing systems and identified common problem areas. Such an analysis would have served as the basis for focusing the document on both meeting the descriptive requirements of law as well as examining options for eliminating and mitigating potential impacts.

B.6.3 Implementation Contextual Factors

The seven factors discussed in this section are commonly cited in the implementation literature as being important for understanding an implementation process. Observations

concerning the impact of each factor on the pollution prevention implementation efforts at LASC are presented below. The observations are relative to LASC's implementation of its internal pollution prevention policies as well as government requirements.

B.6.3.1 <u>Organizational Structure and Relationships</u>

The F-22 program is managed using a product oriented structure as shown in Figure B.4.

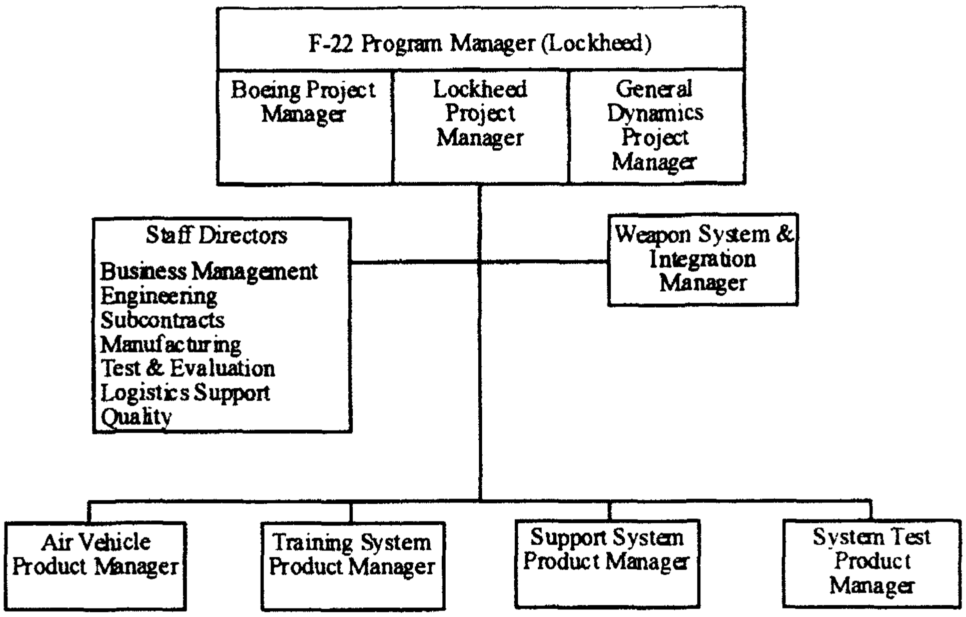

Figure B.4. F-22 Team Program Organization

The development team is headed by the Lockheed F-22 Program Manager, a Lockheed Vice President. Working with the Program Manager, are three corporate project managers representing LASC, Boeing, and General Dynamics (now Lockheed Fort Worth Company). Below the Project Managers, are four Product Managers.

The F-22 Hazardous Materials Manager works several levels under the Engineering Director. The Engineering Director is shown in Figure B.4 as one of the staff directors.

The organizational chain for the Hazardous Materials Manger is shown in Figure B.5.[29] The chain runs from the Engineering Director through system safety. This arrangement has clear advantages and disadvantages.

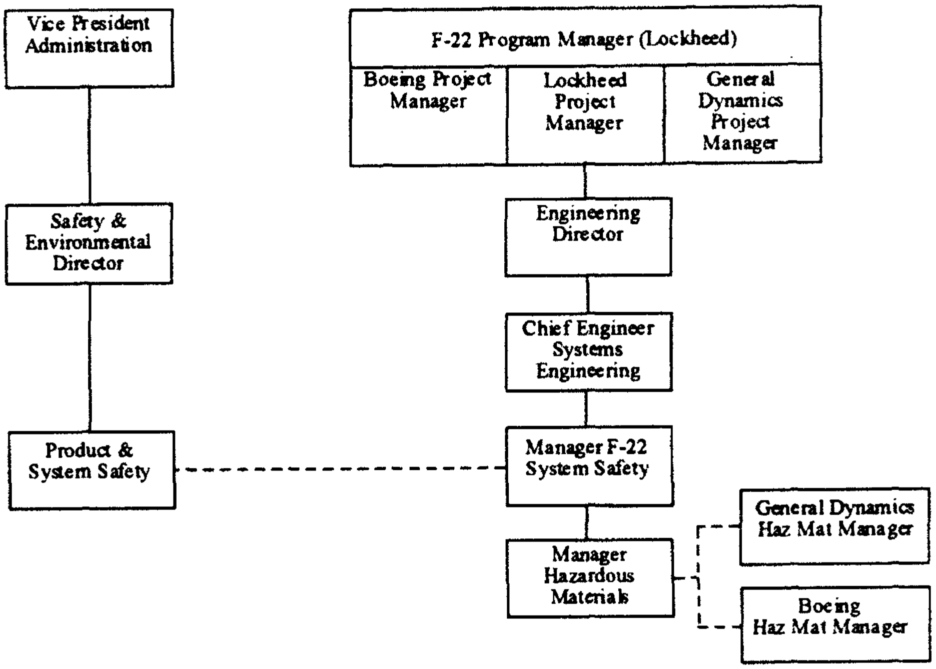

Figure B.5. F-22 Hazardous Materials Organization

The major advantages to having hazardous materials management within system safety is that both system safety and hazardous materials are concerned with material hazards and both are small functions that must support a large number of IPTs. With some cross training, this allows additional people to be used in the hazardous materials role.

The major disadvantage is that the issues and technical information the IPTs need is probably better supplied by a materials and processes engineer than by a safety engineer. Not surprisingly, the F-22 hazardous materials managers at each company (LASC, The

[29] Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," 3-3.

Boeing Company, and Lockheed Fort Worth Company) all have backgrounds in materials and processes.

B.6.3.2 Goal Structure

The five steps in LASC's identification-evaluation hazardous-materials process form the basis of the F-22 Hazardous Material Program's goals and are shown in Table B.8.[30] A detailed diagram of the identification-evaluation process is shown in Figure B.6.[31]

#	**Objective**
1.	Identify and Evaluate Hazardous Materials
2.	Eliminate, Minimize, Mitigate, Significant Hazardous Materials Affecting the Air Force
3.	Integrate Environmental, Health, and Safety Requirements with Design Process
4.	Support Air Force Logistics
5.	Establish Hazardous Materials Data Base

Table B.8. LASC Hazardous Materials Program Objectives

Objectives one, three, and five are under the control of LASC and have been well implemented. Objectives two and four, require input from the Air Force, to define which materials and processes are significant and what support the Air Force logistics community requires to manage hazardous materials. So far, neither LASC nor the Air Force have devised a satisfactory method of obtaining this input.

[30]Ibid., 4.

[31]Ibid., 7-15.

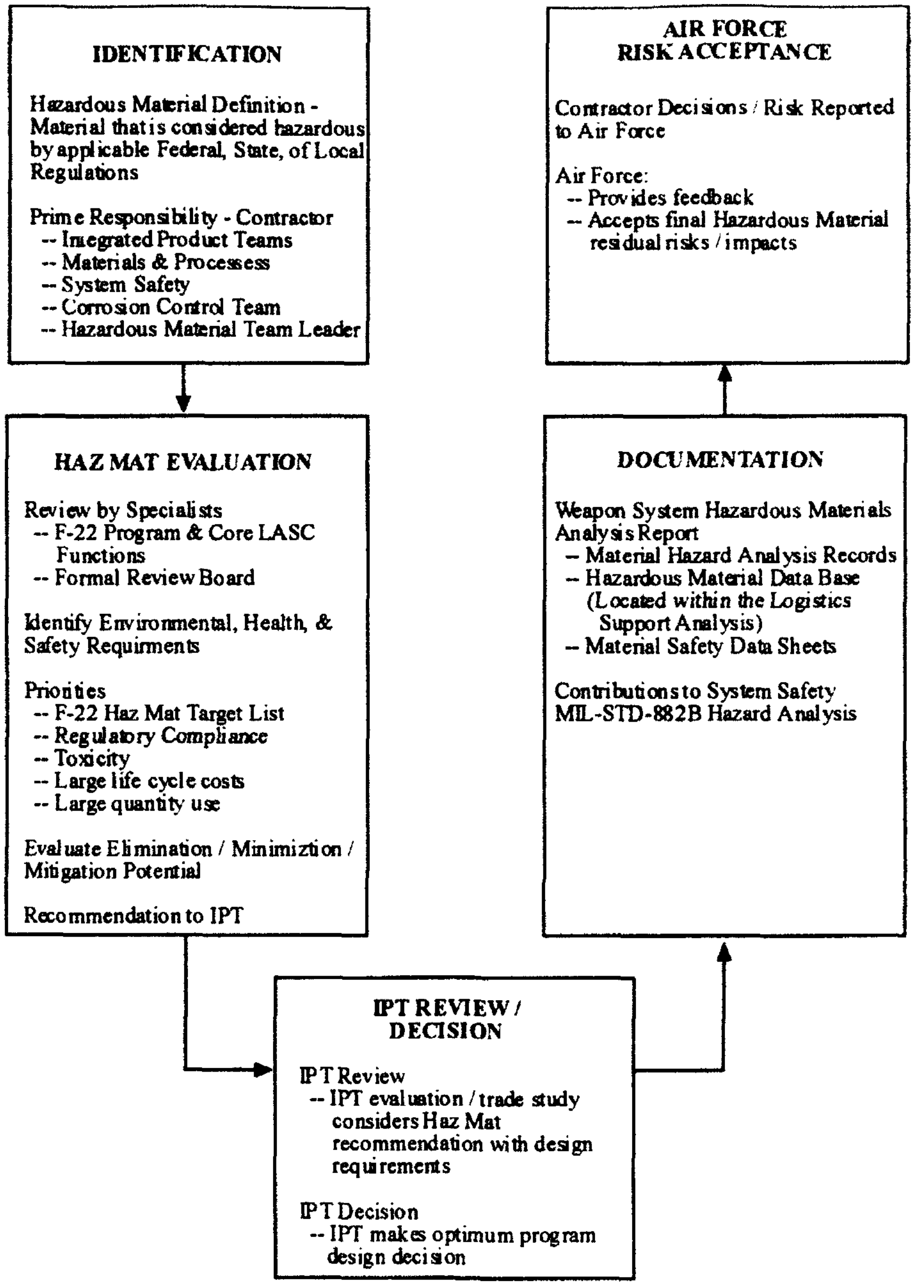

Figure B.6. F-22 Program - Detailed Material Review Process

B.6.3.3 Knowledge Base

The range of professional skills represented on staff at LASC, as well as at the other aerospace companies visited, is impressive. The staff includes a wide variety of scientists, engineers, professionals, and managers. Skill level is clearly not an issue.

Access to needed data is another matter. For example, LASC recently supplied the Air Force a kit for modifying the potable water system on the C-5B transport aircraft. The kit contained everything needed to make the modifications. One step in the modification involved making a new hole in the interior aluminum floor of the C-5B aircraft. To prevent corrosion around the new hole, a potting compound was specified. Emissions from the solvent used in the potting compound exceeded air emission requirements in California. Engineers at LASC were unaware of the California requirements. Workers at Travis Air Force Base in California recognized the problem and asked LASC for an alternative potting compound, but none was readily available. The solution was to make the modification to the California-based aircraft in another state. The root cause of the problem is that the only environmental compliance requirements that are readily available to designers at LASC are the Federal and state of Georgia regulations. Information on environmental compliance requirements at other locations is not available. This lack of data indicates a continuing focus on the manufacturing portion of a product's life cycle.

The F-22's Hazardous Materials Program (HMP) addresses this issue by setting up a coordination process between LASC and the Air Force (AF) on hazardous materials (HMs) compliance issues.

> The HMP shall coordinate, via the AF F-22 Focal Point, with AF Logistics base representatives to address AF user environmental compliance and hazardous materials concerns. The AF Base representative(s) will provide guidance regarding the AF base compliance of HMs proposed by the F-22 program in a timely manner. The F-22 shall use this AF guidance as the regulatory (including AFOSH) compliance determination for these HMs. The F-22 HMP will rely on AF guidance regarding the regulatory compliance of HMs used at AF bases.[32]

This coordination process does not work and it will probably never work for the intended purpose. The coordination process is an "after-the-decision" process. As such,

[32]Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan," 3-6.

it will never provide timely input to the design process. Another problem with the approach is that while representatives at he logistics depots are knowledgeable about compliance requirements at their own bases, they have no source of data on the compliance requirements for bases located in other states.

In addition, the military's depots are large industrial complexes with environmental concerns similar to the aircraft manufacturer's concerns. The depots are not representative of the Air Force's operating installations. The depots have large industrial areas that employ thousands of works and have correspondingly large environmental staffs. An environmental staff of fifty is not uncommon. Operating installations are more like commercial airports. Their primary purpose is to operate aircraft. Industrial activity is limited to regular maintenance activities and operating installation environmental staffs are small, usually consisting of between five and ten workers. Thus, the F-22 coordination process provides neither timely nor complete environmental compliance information.

B.6.3.4 Resources

Resources for pollution prevention are constrained both within the F-22 program and LASC wide. Within the F-22 program, the primary constraint is funding.

At a time of declining defense budgets, the F-22 must be affordable. The program faces higher unit costs due to a declining requirement for the total number of aircraft to be built and because of increasing overhead costs.[33]

The need to reduce overhead could reduce the level of environmental technical support available to the F-22 from corporate resources. Much of the environmental technical capability at LASC is located in the core functional areas of the company and at

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[33]Due to the overall decline in the value of military contracts, contractor general overhead costs are a significant problem for the F-22 and other acquisition programs that survive the budget ax. As the defense business base declines in a company, the level of overhead must decline commensurately, or overhead costs for the remaining programs will climb. These cost are then passed on to the government under the cost plus type contracts used on most development contracts, including the F-22.

LASC's sister Lockheed companies. What ever the source of the support, the time available must shared among all programs as support is needed. With the simultaneous decline in orders for new aircraft from the airlines, corporate staffs are being reduced at all of the major companies building the F-22. So far, LASC's environmental staff has not been cut, but getting additional people to work on pollution prevention has been difficult.

In addition to overhead costs, direct costs are also an issue. An example of where direct costs are impacting pollution prevention can be seen in the F-22's landing gear. The specification for the surface finish on landing gear parts was developed during the demonstration / validation (Dem/Val) phase of the program. The Air Force approved cadmium plating as the baseline finish on F-22 landing gear high strength steel parts exposed to temperatures above 450 degrees Fahrenheit. This finish has excellent corrosion resistance properties.

The landing gear for the Dem/Val prototype aircraft were manufactured by the Menasco Aerosystems Division of Coltec Industries using cadmium plating. Shortly after Lockheed was awarded the EMD contract, a subcontract was awarded to Menasco to produce landing gear for the program using the baseline finish.

Later, after EMD was underway, the Air Force supplied Lockheed with its target list of chemicals for reduction and cadmium is one of the chemicals on the list. The fact that the Air Force wanted to reduce or eliminate cadmium use was presented to the Landing Gear IPT in December 1992. In addition, the environmental staff at Hill AFB, the depot for repair of all landing gear in the Air Force, asked that cadmium not be used on the F-22's landing gear.

The principle alternative to cadmium plating is an ion vapor deposition (IVD) coating of aluminum. Even though IVD aluminum is an approved finish for use on high strength steel parts exposed to temperatures below 925 degree Farenheight in the F-22 finish specification, Manasco does not have the capability to apply IVD aluminum in-

house. Manasco does have the capability to apply cadmium plating in-house.[34] Directing Manasco to replace cadmium plating with IVD aluminum would require a contract change and would result in both cost and schedule impacts. Because of this, the IPT is not willing to direct that the switch be made.

Instead, the landing gear IPT provided the Air Force a brief summary of the problem and a rough estimate for performing a detailed cost and schedule impact study. Since the properties of IVD aluminum for this application are well understood, there is no need for material testing. The Air Force program office considered the issue and has, so far, decided not to fund the study or to direct a change. In analyzing the issue, the program office worked with managers at Hill AFB to try to quantify the life cycle cost savings to the Air Force for making the switch.

The results of the study were sensitive to the assumptions made in the analysis. Hill AFB has a cadmium plating capability and currently plates the landing gear for many different Air Force aircraft. Once the F-22 is fully operational, Hill estimates that approximately 25 percent of its landing gear work load will be from the F-22. The issue is whether any real savings can be achieved at Hill by eliminating cadmium from the F-22, since the base will still have to manage and treat cadmium plating wastes that are produced from plating the landing gear from the other types of aircraft.

Thus, the analysis hinges on assumptions and decisions outside the control of the program office. Among Hill AFB's options are to continue operating the cadmium plating process; working to eliminate all cadmium plated parts from all the systems, thus, removing the need for the process; or contracting for cadmium plating services. Hill's plan for reducing its use of cadmium is not complete.

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[34] Arline Denny, letter to T. Grady, F-22 System Program Office, "Cadmium Plating of F-22 Landing Gear," (Marietta, GA: Lockheed Aeronautical System Company, 1 February 1993).

Had the issue been addressed prior to EMD, other companies could have bid on providing IVD aluminum parts. If Lockheed wanted to continue its relationship with Manasco, a partner in the Dem/Val program, Manasco could have elected to bid on the EMD work based on using its own subcontractor for the finish instead of doing it in-house. In the end, the Air Force may well accept cadmium plated landing gear on the F-22. Clearly this result could have been avoided by including the environmental requirements earlier in the contract and by addressing specific environmental issues instead of contracting only for a hazardous materials management process.

B.6.3.5 Dispositions

The disposition of LASC employees toward environmental issues was observed during each interview and was evaluated using a questionnaire during the site visit. Results of the questionnaire are presented in detail in Appendix F. A summary of the survey results is presented below.

The questionnaire consisted of a total of 27 questions and contained questions on six general topics: environmental behavior, environmentalism, environmental concerns, pollution prevention, and environmental performance. Twenty of the 27 questions were taken from national surveys on the environment. A brief summary of LASC's data is presented below.

At LASC, the employees answered nine of twenty questions differently than people in a national random sample. In this study, finding five or more answers that are different from the national data is assumed to be an indication that employees have a different disposition toward the environment than the national average. Note that there are no "right" or "wrong" answers to the questions and that different is relative to the question asked--different behaviors, different concerns, etc. As a result of evaluating the survey

data[35] and the information gathered during the interviews some general conclusions can be drawn.

First, the employees tend to believe that the condition of the environment is getting better. Therefore, they are less worried about the environment than people nationally. They also believe that, in general, business, industry, and the Government all spend too much time worrying about the environment, but that their company is not enough worried. They are keenly aware of the costs associated with environmental compliance and they believe that environmental regulations can go too far. Thus, they are less willing to pay higher taxes or to see job losses because of environmental regulations. They do volunteer work for environmental groups as often as the national sample, and are even more likely to voluntarily participate in recycling programs. LASC was the only company were less than half of the respondents believe that the company does not worry enough about the environment. Finally, and most importantly, almost 90 percent believe that the company strongly supports efforts to prevent pollution and that more time should be spent on environmental issues.

Summarizing the survey data, the employees at LASC display different views than those found in the national surveys. On balance, they have a more positive outlook on the condition of the environment, are less worried, and are less likely to consider themselves environmentalists. On the other hand, respondents believe that the company is concerned about the environment, they strongly support the company's pollution prevention efforts, and they want to do more.

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[35]Note that there are three sources of potential bias with the survey results. First, the data collected at LASC does not represent a random sample. Second, the questionnaires were distributed in the work place while the national data are from telephone surveys. This biases the definition of "environment," since environment is not defined (it may mean the local environment, national environmental, global environment, etc.). On the questionnaire, respondents appear to assume that several questions are referring to the work place environment. This would not occur in the telephone survey. Finally, there is a bias toward professional and management employees among the respondents. At LASC, 95 percent of the respondents identified themselves as managers, engineers, or other professionals.

In conclusion, the results of the survey and interviews indicate that, in general, the employees: 1) understand the policy, 2) they either accept the policy or are neutral, and 3) that they do not have strong negative feelings about environmental issues. This supports the research assumption that LASC's pollution prevention policies will not fail because the implementors have strong negative feelings about them.

B.6.3.6 Decision Making and Management Procedures

Most design decisions are made within the IPTs. The goal of the IPT decision making process is to make balanced decisions after considering all competing requirements. Within this process all requirements do not carry equal weight, however. Interviews with IPT leaders and members suggests that within the air vehicle portion of the F-22 program, design decisions are often made using a three level priority scheme for the decision making criteria as shown in Table B.9. Meeting quantitative contract requirements is the most important criteria. Weight and cost tie for second place in importance behind contract requirements. Although aircraft weight is not subject to a firm contract requirement on the F-22, it is still very important since it directly impacts a host closely related operational performance requirements that are specified in the contract (speed, range, etc.).

Priority	Decision Criteria
1.	Does it meet contract requirements?
2.	Is it the lightest weight solution? Is it the lowest cost solution?
3.	All other criteria.

Table B.9. Integrated Product Team - Priorities for Design Decisions

Within the overall cost criteria, there are several unequal considerations. The most important cost element is contractor's cost in the engineering and manufacturing

development (EMD) contract. This is the cost directly chargeable to the current contract and covers the contractor's on-going engineering and testing costs. Second, behind the EMD cost, is the design-to-cost for the part or component. This is the "target" average unit cost for producing the item in a production program. Finally, the IPT considers life cycle costs. For the most part, however, life cycle costs play a small role in most IPT decisions since life cycle costs are not currently tracked for most parts, components, or subsystems.

Pollution prevention falls into the last category. The contract requires LASC to operate a hazardous materials program that includes management and reporting requirements, but no quantitative requirements that can be allocated to the IPTs.

A good example of the impact of a "priority one" criteria is the F-22 requirement stating that torque wrenches shall not be required for organizational level maintenance tasks. Organization level maintenance refers to maintenance that occurs on the flight line This requirement was included in the F-22 contract to reduce flight line maintenance time and to eliminate potential problems associated with not following proper procedures in using torque wrenches.

This requirement caused a direct impact on the design of the metal avionics racks that hold electronic components in the F-22. The engineer's initial design called for a common alloy that had been successfully used for the same purpose in the past. Unlike past avionics racks, the F-22's racks include a liquid cooling system to remove excess heat from the electronic components. To simplify maintenance, the cooling liquid is supplied to the racks using hoses with quick disconnects. Over the life of an aircraft, the logistics engineers estimated that the system would experience four to five failures of the quick disconnect fittings. The problem arose when the engineers realized that replacing a quick disconnect fitting without a torque wrench could damage the avionics rack. The rack is worth hundreds of dollars while the fitting costs a few cents. The possibility of damage arose because the threaded fitting was made of a higher strength alloy than the rack.

Thus, if the fitting was over tightened, as a result of not using a torque wrench, the female threads on the rack could be stripped.

Challenged by this, the IPT looked at both the fitting and rack. When an alternative fitting could not be found, the IPT looked at redesigning the rack. The rack will now be fabricated with a higher strength material. Now if a fitting is over torqued, the fitting will fail instead of the rack. In addition to meeting the logistics requirement, the new design is both less expensive to build and lighter! The material thickness in the rack was decreased, taking advantage new material's increased strength. This reduced weight. Cost was also reduced since the higher unit price of the new material was more than offset by the reduction in the mass of material needed.

This example illustrates three key points: 1) the successful operation of the IPT, 2) a successful iterative design process that worked to satisfy a wide range of design requirements, and 3) the impact of a firm design requirement.

B.6.3.7 Communications

Communications on hazardous materials issues is strong and improving at LASC. As recently as 1988, workers at LASC had limited access to information on hazardous materials in the work place. Material safety data sheets (MSDSs) were not available in most shops, many procedures did not explain how to use hazardous materials safety, and training on hazardous materials issues was not common. Today, this has all changed.

LASC has a strong hazardous materials management and control program. Three elements in particular stand out, and all three are having a positive impact on communications. First, new computer hardware has been purchased to allow all MSDSs to be electronically scanned and stored. This will allow every MSDS at LASC to be available on-line. This is a great resource for both workers and designers, and solves the problem of updating paper MSDSs as they change. Second, hazardous material receiving, storage, and issue have been consolidated in one organization within Operations. Staffed

by well trained workers, the new Hazardous Materials Management function will provide close control of all hazardous materials from the time they are brought on site until they are either used in products, recycled, or disposed. Finally, the Hazardous Materials Review Board (HMRB) has had a profound impact on opening communications on hazardous materials issues at LASC.

The HMRB has achieved this by accomplishing its tasks efficiently and professionally. The review process for a new material is extensive and involves coordinating the efforts of many functional areas. The staff has been able to keep the length of time needed to complete a review and get the information to the board for a decision relatively short, usually under a month. When needed, the review process has been accomplished in less than a week. In addition to being timely, there is a knowledgeable and professional staff involved in the review process. This results in an impressive amount of factual information being put together for decision making. Among the F-22 staff members interviewed, the HMRB process is well respected for providing documented, factual information and timely responses.

B.7 Annex to Appendix B -- Text of Contract Pollution Prevention Requirements

Paragraph 3.4.1.10 of the F-22 Statement of Work, Contract F33657-91-C-0006, defines the hazardous materials program requirements.

> **Hazardous Materials Program.** (WBS 41AO). The contractor shall develop, maintain, and update a Hazardous Materials Program (HMP) as defined in the approved Hazardous Materials Program Plan (HMPP) and described in the HMP narrative Integrated Master Plan. The contractor shall integrate the HMP into all aspects of the FSD program, including those of associates, subcontractors and suppliers, focusing on elimination of hazardous materials, where possible, or mitigation of consequences as appropriate. The contractor shall coordinate the HMP with the System Safety Program Plan and appropriate specialists including toxicologist, chemists, materials and processes analyses, environmental impact and occupational safety/health personnel. The Contractor HMP shall address the entire life cycle of the weapon system to ensure optimization and balance between design parameters and hazardous materials constraints. The Contractor HMP shall comply with regulatory requirements (AFOSH/OSHA) to include transportation,

storage, use and disposal of hazardous materials and waste identified as part of the weapon system or its support requirements. The contractor HMP shall include tasks that address identification, evaluation and use of hazardous materials, the disposal of hazardous waste, mishap procedures, and how this will be reported to the Government. The Contractor shall develop and maintain a listing of all hazardous materials (including the amounts and exposure limits) used/produced during this program and prepare Hazardous Materials Analyses Reports as required by the CDRL. The Contractor shall summarize results of analyses and trade studies and their impact on design for inclusion in the Air Vehicle/System/Subsystem Environmental Impact Report, and provide hazardous materials inputs to the Weapon System Occupational Safety and Health Assessment. Reporting requirements shall be in accordance with the CDRL (OT-90-34206, OT-90-34208).[36]

The work breakdown structure (WBS) code, listed at the beginning of the paragraph, identifies the tasking in the program management system. The integrated master plan (IMP) narrative is a contractor prepared document that is used to define and track program requirements. The codes listed at the end of each paragraph, such as OT-90-34206, are data item descriptions (DIDs) that provide information to the contractor on how the information required by the SOW is to be provided to Government. Definitions for the DIDs are individually specified in another portion of the contract using one or more copies of Department of Defense Form 1423-1. For example, OT-90-34206, provides information on the Hazardous Materials Program Plan. The form specifies the time allowed for the contractor to develop the plan, and for the Government to review the contractor's submittal. In addition, the DID defines the plan's format, the number of copies to be submitted, and identifies the offices to receive a copy.

[36]Lockheed Aeronautical Systems Company, "F-22 FSD Statement of Work," 33-34.

APPENDIX C

CASE STUDY ON LOCKHEED FORT WORTH COMPANY

Fort Worth, Texas

F-16 Fighting Falcon and F-22 Advanced Tactical Fighter (ATF)

C.1 Introduction

Lockheed Fort Worth Company (LFWC), an operating company within the Aeronautical System Group of Lockheed Corporation, builds the F-16 fighter and has a one-third share in development of the F-22. LFWC's principle facilities at Fort Worth, Texas are owned by the Air Force and operated by Lockheed. The government facilities are known as Air Force Plant 4 (AFP-4) and are located on 602 acres adjacent Carswell Air Force Base (AFB). The plant began operation on April 18, 1942 producing B-24 Liberator bombers.[1] Over the years B-24, B-32, B-36, B-58, F-111, and F-16 aircraft have been produced at the 7 million square foot plant. Currently only the F-16 is in production, but a portion of the facility is being prepared to produce center fuselage sections for the F-22.

C.2 Case Study Organization

The remainder of the case study is organized into six major sections: 1) Program Overview, where general background information is provided for each program included in the study; 2) Corporate Background, where information on the parent corporation is presented; 3) Data Gathering, which provides information on how and when the study

[1]Lockheed Fort Worth Company, "Air Force Plant 4 History," information sheet, (Fort Worth, TX: Lockheed Fort Worth Company, 1993) 1-2.

data were collected; 4) Results and Analysis, where the details of the case are presented, 5) Summary; and 6) Text of Contract Pollution Prevention Requirements.

The heart of the case study, the Results and Analysis section, begins with a presentation of the relevant program contract requirements and corporate policies. The section continues with the organizational setting, features of the pollution prevention program, the corporate environmental record, and pollution prevention results. The final portion of section includes a separate analysis on each of seven different implementation factors.

C.3 Program Overview

This case study addresses the F-16 production program and the F-22, which is still in development. The current status of both programs is summarized in Table C.1

Program	Acquisition Phase	Contract Pollution Prevention Requirements
F-16	Production	None
F-22	Engineering & Manufacturing Development	Extensive Hazardous Materials Program

Table C.1. Program Status Summary

C.3.1 F-16 Fighting Falcon

The F-16 Fighting Falcon is a single-engine, multirole tactical fighter[2] that has been produced in large numbers.[3] As of February 1993, a total of 3,980 F-16s had been ordered by eighteen countries.

[2]The F-16C has a wing span of 31 feet, is 49.3 feet long, and has an empty weight of 19,517 pounds. The aircraft's light weight is achieved without extensive use of exotic materials. The structure is about 80 percent aluminum, 10 percent steel, 3 percent composites, and 0.5 percent titanium, with other materials, such as glass and rubber, making up the reminder. It was the first fighter to employ fly-by-wire flight control, a blended wing-body, relaxed static stability, and side-stick flight controls.

[3]Production of the F-16 peeked in the mid-1980s at approximately 30 aircraft per month. By the end of 1993, the production rate was down to about ten aircraft per month. The Air Force had planed to

The program was initiated in 1972 to meet the Air Force's requirements for a low-cost, high-performance aircraft to complement the F-15 Eagle. The Air Force selected the General Dynamics F-16, following a fly-off with the Northrop F-17, in 1975. A few months later, Belgium, Norway, and the Netherlands also decided to buy the F-16, ensuring a large production run. The operational first aircraft was delivered 1978.[4] The 1000th aircraft was delivered in 1983, the 2000th in 1988, and the 3000th in 1991.

C.3.2 F-22 Advanced Tactical Fighter

The F-22 is being developed[5] to be the Air Force's next-generation air-superiority fighter, a follow-on to the current F-15 fighter.[6] The aircraft is highly maneuverable at both subsonic and supersonic speeds and it incorporates stealth technologies as well as a host of other technological advances in avionics, engines, and other systems.

In August 1991, the Air Force awarded a Lockheed-led contractor team an Engineering and Manufacturing Development (EMD) contract valued at approximately $9.5 billion to complete development of the F-22 over a nine year performance period. By agreement among the companies, the team divided the program into roughly thirds

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purchase two aircraft per month through the mid-1990s, but the President's proposed Fiscal Year 1995 budget would end Air Force purchases. Total production should level off at around five aircraft per month to meet foreign demand until about 2000. The program's future beyond 2000 is uncertain.

[4]F-16s have been assembled in the United States (LFWC), Belgium (SABCA), the Netherlands (Fokker), and Turkey (TUSAS Aerospace Industries, Inc.). A Korean factory will begin deliveries in the late 1990s. An F-16 derivative, the FS-X, is being developed by Mitsubishi Heavy Industries with assistance from LFWC for Japanese use.

[5]Air Force requirements for the F-22 started to take form in about 1980. Concept definition contracts were awarded in 1984 and were followed by Demonstration/Validation (Dem/Val), Phase I, contracts to two teams: Lockheed/Boeing/General Dynamics and Northrop/McDonnell Douglas. In April 1991, Phase I was completed with the selection of the Lockheed team by the Secretary of the Air Force as the winner of the prototype "fly-off" between the Lockheed/Boeing/ General Dynamics YF-22 and Northrop/McDonnell Douglas YF-23. At the same time, the Pratt & Whitney F119 engine was selected over General Electric's entry to power the F-22.

[6]The F-22 is 62.5 feet long and has a wing span of 44.5 feet, approximately the same size as the F-15. Key design features of the F-22 include: using stealth, low-observable, technologies; supercruise (the ability to fly faster than mach 1 without afterburner); engine thrust vectoring; increased payload and range over the F-15; better maneuverability than the F-15, advanced integrated avionics capable of performing beyond-visual-range as well as close-in-combat missions, and internal carriage of weapons.

between Lockheed, Boeing, and General Dynamics. Within the team, Lockheed is the leader and system integrator. The first EMD aircraft is currently scheduled to begin flight testing in 1996.

During the Concept Definition and Demonstration/Validation phases of the program, there were no hazardous materials or other pollution prevention requirements in the contracts. Beginning with the EMD contract, the Lockheed team was tasked to initiate a Hazard Materials Program (HMP). The goals of the HMP are to eliminate the use of hazardous materials where possible and to mitigate the consequences of using hazardous materials as appropriate.

C.4 Corporate Background

In December 1992, Lockheed Corporation announced that it had reached an agreement with General Dynamics (GD) to purchase GD's tactical military aircraft business for $1.525 billion. The sale closed on March 1, 1993, and the General Dynamics, Fort Worth Division, became the Lockheed Forth Worth Company (LFWC).

In acquiring the Fort Worth Division, Lockheed gained control of General Dynamics' one-third share in the F-22 fighter program; the F-16 fighter program; the FS-X program, a joint venture between the United States and Japan to develop a F-16 derivative; and other smaller programs.

In 1992, General Dynamics (GD) reported total sales of $8.696 billion and earnings of $815 million. Of this total, GD's tactical military aircraft business produced earnings of $193 million on sales of $5.224 billion.[7] A summary of GD's recent overall financial performance together with the performance of its tactical military aircraft business is

[7]General Dynamics, "1992 Shareholder Report," (General Dynamics Corporation: Falls Church, VA, 26 March 1993), 28.

shown in Table C.2.[8] The declining net sales in the tactical military aircraft business is the result of declining sales of the F-16, the Fort Worth Division's main product.

Dollars are in millions

	1992	1991	1990
General Dynamics			
Net Sales	$8,696	$8,751	$9,457
Net Earning	$815	$505	($578)
Tactical Military Aircraft			
Net Sales	$5,224	$6,266	$7,038
Net Earnings	$193	$299	($377)

Table C.2. General Dynamics Financial History

Lockheed Corporation had total sales of $10.1 billion in 1992, of which $3.0 billion came from its aeronautical business. This made the Aeronautical Systems Group the second largest in the corporation after the Missiles and Space Group with sales of $4.6 billion. The Technology Systems Group and the Electronic Systems Group each had sales of approximately $1.3 billion. With the addition of the new Lockheed Fort Worth Company, the Aeronautical Systems Group will be the largest Group in terms of sales in 1993. In addition, the acquisition is projected to make Lockheed Corporation the largest United States defense contractor in terms of prime contract awards for 1993.[9] For 1992, Lockheed was the third largest prime contractor behind Northrop and McDonnell Douglas.

[8]General Dynamics, "1991 Shareholder Report," (General Dynamics Corporation: Falls Church: VA, 12 March 1992), 26.

[9]G. J. Reich, "Industry Report," Pegasus, (New York, NY: Shearson Lehman Brother, 11 May 1993) 3.

C.5 Data Gathering

Data for the case study was obtained during a site visit to LFWC from 27 October to 4 November 1993. During the visit, fifteen people were interviewed, production operations were observed, and 34 questionnaires were completed by LFWC personnel. The visit was sponsored LFWC and supported by the Air Force's F-16 program office.

C.6 Results and Analysis

C.6.1 Policy Framework

C.6.1.1 Corporate Environmental and Pollution Prevention Policies

At the corporate level, Lockheed's environmental policy is contained in Corporate Management Policy Statement (CMPS) Number 173, "Environmental, Safety, and Health Protection."

> In is the policy of Lockheed Corporation to be a good neighbor, employer, and corporate citizen by managing all phases of our operations to minimize adverse effects on the environment and the safety and health of our employees, customers, and communities surrounding our plants. It is also the policy of Lockheed Corporation to comply with applicable federal, state, and local laws and regulations related to the environment, safety, and health.
>
> The management of each company is responsible for managing its operations to assure compliance. . .[10]

The policy provides only broad guidance and does not address pollution prevention or other forms of waste reduction. In 1991, Lockheed committed itself to meeting the voluntary chemical release reduction goals in EPA's 33/50 Program. Since, General Dynamics was also a participant in the 33/50 Program, the change in ownership had little impact on environmental management activities at LFWC.

[10]R. A. Fuller, Vice Chairman of the Board and Chief Operating Officer, "Environmental, Safety, and Health Protection," Management Policy Statement Number 173, (Calabasas, CA: Lockheed Corporation, 13 November 1989), 1.

In addition, while Lockheed has only recently shown a corporate commitment to pollution prevention, LFWC has benefited from General Dynamics' history of stronger corporate environmental leadership. At LFWC, the environmental management function is call Environmental Resource Management (ERM).

> The ERM Program began when a General Dynamics (GD) corporate team was chartered with the task of assessing the impact of future environmental trends on the aerospace industry. Among the team's projections were (1) an exponential increase in hazardous waste disposal costs, (2) a dramatic reduction in disposal alternatives, and (3) an ever increasing long-term liability associated with disposal of hazardous waste.
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> Driven by these three findings, a corporate policy was established to reduce or eliminate the use of hazardous materials and the generation, discharge, and disposal of hazardous waste. The vision and ultimate goal was to achieve "Zero Discharge" of hazardous waste and emissions. This policy was implemented in 1985 because, according to GD's then Chairman and CEO Stanley Pace, "it makes good business sense."[11]

To support the pollution prevention portions of its Environmental Resource Management (ERM) program, LFWC has issued a number of policy documents. Table C.3 lists LFWC's pollution prevention-related policies and shows the overall hierarchy of policies. Among the companies visited, LFWC had the most well developed set of environmental policies and procedures.

Having a large body of written policy could be viewed as unnecessarily bureaucratic, but this does not seem to be the case here. Complying with environmental regulations and implementing pollution prevention in the factory requires a well trained work force and training the work force is dependent on having established procedures.

Controlling volatile organic compound (VOC) emissions from hand wipe cleaning solvents is a good example of where developing and using standard procedures is necessary. The proper handling and segregation of hazardous wastes is another example.

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[11]Kevin R. McKee and Stephen P. Evanoff, "Environmental Resource Management at Lockheed Fort Worth Company (1984-1993)," in Proceeding of the Fifth Annual Environmental Management and Technology Conference/Southwest, held at Dallas, TX, 28-30 September 1993, (Glen Ellyn, IL: Advanstar Expositions, 1993), 179.

Corporate Management Policy Statements (CMPS)	
CMPS 173	Environmental, Safety, and Health Protection
CMPS 61	Corporate Environmental Policy and Awareness Committee
LFWC Standard Practices (SP)	
SP 10-50	Environmental Resources Management
SP 10-51	Hazardous Material Control and Elimination
SP 10-55	Polychlorinated Biphenyl (PCB) Control
SP 10-56	Hazardous Waste
SP 10-57	Volatile Organic Compound (VOC) Emission Tracking System
SP 10-59	Underground Storage Tanks
Company President Notices (DN)	
DN 93-2	Hazardous Materials
DN 91-43	Division Hazardous Material Management Program
DN 89-26	Hazardous Chemicals
DN 88-42	Integrating Environmental Resources Management into All New Programs
DN 84-40	Environmental Resources Management
Process Standards (PS)	
PS 81.02	Hazardous Waste Accumulation Procedures
PS 81.04	Waste Jet Fuel Handling and Disposal
Safe Practice Instructions (SPI)	
SPI 104	Radioactive Waste
SPI 206	Mercury Spills
SPI 211	Labeling of Hazardous Chemicals
SPI 300	General Waste Management
SPI 301	Waste Management Training
SPI 302	Waste Management Inspections
SPI 303	Waste Identification / Analysis Classification
SPI 304	Waste Accumulation Points
SPI 305	Waste at Satellite Facilities
SPI 306	In-Plant Waste Movement and Storage
SPI 307	In-Plant Waste Processing
SPI 308	Waste Shipment and Disposal
SPI 309	Trash and Garbage Management
SPI 310	Sanitary Sewers and Storm Drains
SPI 311	Dust, Fumes, Mists and Gaseous Wastes
SPI 312	Industrial Waste Collection System

Table C.3. LFWC Pollution Prevention Policies

Among the policies listed in Table C.3, SP 10-52, "Hazardous Material Control & Elimination" is the most important for pollution prevention. The standard practice states that LFWC,

> Plans to ban, eliminate or reduce the use of hazardous materials. These materials are listed in Attachment A, Hazardous Material Elimination List.

Organizations are required to used this list as a reference at the outset in the planning phase of any task that may involve the acquisition or use of chemicals or hazardous materials. The goal is to eliminate hazardous materials at the very beginning in the design of products and facilities, in the selection of materials and equipment, and in the development of operating procedures.[12]

To implement this policy, SP 10-52 establishes a Hazardous Materials Management Program Office (HMMPO). The HMMPO operates like an integrate product team (IPT) in implementing pollution prevention at LFWC.

The Minnesota Guide to Pollution Prevention Planning, written by Terry Foecke, a leader in developing pollution prevention implementing strategies, states that a pollution prevention policy statement should provide a clear understanding of, 1) why a pollution prevention program is being implemented, 2) what will be done, and 3) who will do it.[13]

LFWC Standard Practice (SP) 10-52, "Hazardous Material Control & Elimination" meets all three of Foecke's criteria. First, the program is being implemented to eliminate hazardous materials and the resulting liabilities, wastes and emissions. Second, the purpose of the pollution prevention program is to eliminate hazardous materials at the very beginning in the design of products and facilities, in the selection of materials and equipment, and in the development of operating. Finally, the policy tasks the Hazardous Materials Management Program Office (HMMPO) to implement a program to ensure progressive elimination of hazardous materials and tasks affected departments to comply.

The policy is the strongest seen at the four companies visited, but it could be strengthened. The Environmental Resource Management (ERM) office has adopted the slogan, "ERM is Everybody's Business." This concept should be expressed in the policy. In addition, ERM has retained its strategic "Zero Discharge" goal developed while it was a part of General Dynamics: "Zero Discharge of hazardous materials to the environment is

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[12]Gordon England, President, Lockheed Fort Worth Company, "Hazardous Material Control & Elimination," Standard Practice 10-52, (Fort Worth, TX: Lockheed Fort Worth Company, 3 March 1993), 1.

[13]Terry Foecke and Al Innes, Minnesota Guide to Pollution Prevention Planning, (St. Paul, MN: Minnesota Office of Waste Management, 1992) 2-1.

the vision and long-term goal of the Lockheed Fort Worth Company. . ."[14] This should be stated explicitly in LFWC's written policy. While the company was a part of General Dynamics (GD), this policy had a strong basis in GD's corporate policy and procedures directives. This is not the case at Lockheed. Finally, the policy should clearly address the product life cycle. While design and operations are specifically mentioned, the policy would be strengthened by including LFWC product support functions.

C.6.1.2 Government Pollution Prevention Requirements

The F-16 contract has no pollution prevention or hazardous materials requirements. The F-22 EMD contract requires the F-22 team to conduct a hazardous materials program (HMP) as described in section 3.4.1.10 of the contract statement of work (SOW).[15] The complete text of the section is provided at the end of the case study in paragraph C.7. A summary of the contract pollution prevention requirements is provided in Table C.4.

Program	Contract Requirements
F-16	- None
F-22	- Identify and control hazardous materials --Develop and implement a Hazardous Material Program Plan --Submit data on hazardous materials to the Government --Record decisions on hazardous material uses

Table C.4. Contract Pollution Prevention Requirements

The F-22 Hazardous Materials Program Plan (HMPP) describes how the F-22 team companies intend to meet the contract requirements. According to the HMPP, the objective of the F-22 Hazardous Materials Program (HMP) is to:

[14]Mckee and Evanoff, 179.

[15]Lockheed Aeronautical Systems Company, "F-22 FSD Statement of Work," Section J, Attachment 1 to Contract Number F33657-91-C-0006, submitted to USAF Aeronautical Systems Division, (Marietta, GA: Lockheed Aeronautical Systems Company, 7 March 1991), 33-34.

> Ensure that hazardous material (HM) environmental, health and safety concerns are identified and controlled during EMD by the F-22 team (Lockheed, Boeing, General Dynamics), including its associate and subcontractors, in the design, manufacture, operation, repair, maintenance, support, and disposal phases over the weapon system life cycle.[16]

Additional information on the F-22 HMP is provided in the Lockheed Aeronautical Systems Company (LASC) case study in Appendix B.

C.6.2 Organizational Setting and Scope of Pollution Prevention Activities

C.6.2.1 Organizational Setting

I FWC, unlike the other companies, is basically organized along functional lines. The exception to this is the F-22 program. This functional organization is the result of having only one production program, the F-16, for an extended period of time. As shown in Figure C.1, the environmental function at LFWC is assigned to the Vice President for Human Resources.

The HMMPO operates as an environmental integrated product team (IPT) with two main two roles: 1) a problem solving team, and 2) as the integrator and coordinator of environmental activities at LFWC. The existence of a multi-disciplinary environmental group or committee is nothing new to industry or to government. Getting this type of environmental group to function effectively is much less common. In LFWC's case, several factors have come together to produce a successful program office.

First, the HMMPO has top management support. Second, the HMMPO is a working group charged with solving problems. Too many environmental committees receive reports and coordinate, but are not held responsible for the outcome. Third, LFWC is implementing integrated product development throughout the company. This works to help change the company's culture on working in multi-functional teams.

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[16] Lockheed Aeronautical Systems Company, "F-22 Program Weapon System Hazardous Materials Program Plan,"(Wright-Patterson AFB, OH: Aeronautical Systems Center, 6 March 1992), 2-2, CDRL A001, DI-OT-90-34206, WBS 41A0.

Fourth, and most important, the HMMPO has strong goal-directed leadership. What this means to the pollution prevention program at LFWC is discussed in the next section.

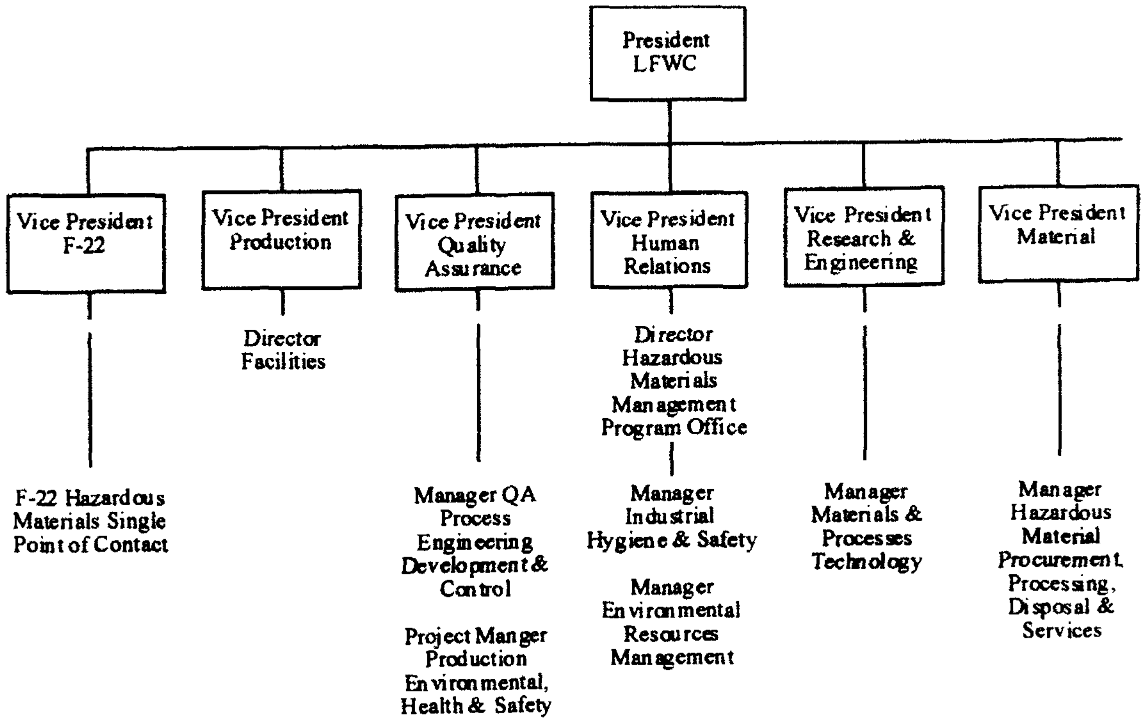

Figure C.1. LFWC Organizational Structure

C.6.2.2 Pollution Prevention Program Scope and Key Features

Management of the environmental program at LFWC is built on goal achievement and this management style is carried over into the pollution prevention program. The degree of focus on goal setting and measuring progress at LFWC is unique among the companies visited. All of the companies track hazardous waste generation, toxic release inventory (TRI) releases, and a few other metrics, but none measure, track, and manage as intensively as LFWC. This feature stands out from among all the other attributes of LFWC's program.

Other important thrusts to the ERM effort include implementing hazardous materials management procedures, working with the research and engineering staffs to develop new

processes and materials, and involving the employees through training and awareness initiatives.

The Hazardous Materials Procurement, Processing, Disposal & Services section is a part of the materials organization, as shown in Figure C.1, and provides comprehensive management of all hazardous materials and hazardous wastes at the plant. All hazardous materials are purchased, received, stored, issued, collected, recycled, salvaged, or disposed by members of the materials organization. Among the companies visited, LFWC has the best defined hazardous materials and hazardous waste management procedures.

The materials organization operates a permitted hazardous waste storage facility on site. Although this would allow hazardous waste to be stored on-site indefinitely, LFWC's goal is to ship all hazardous wastes to a treatment facility within 60 days. Each drum is tracked by waste type and the number of days in storage. Process control charts are used to track the program's status and are updated daily.

The materials organization also has detailed procedures for tracking and issuing hazardous materials to the work areas. Once issued to the work area, hazardous materials become line management's responsibility in the production organization.

Hazardous materials storage and use in the work areas are monitored by the Production Environmental, Health & Safety section. This two person operation is responsible for conducting self-audits of each work area, hazardous material storage area, and hazardous waste accumulation point quarterly. Results are provided directly to the area's supervisor and to the Vice President for Production. The self-audit results are summarized, tracked, plotted, and displayed on process control charts and are briefed to management on a regular basis. This was the only self-audit program observed at the four companies that is conducted by a production organization.[17]

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[17]LFWC, as well as the other companies, all have environmental audit programs conducted at the company or corporate level.

LFWC also has the most comprehensive wastewater and stormwater compliance programs of the four companies studied. In addition, LFWC's pollution prevention program is the only program among the four that addresses water issues. Over the past ten years, wastewater discharges have been reduced from 1,000,000 gallons per day to 300,000 gallons per day, a 70 percent reduction.

The plant has five permitted wastewater outfalls and a member of the ERM staff visits each wastewater and stormwater outfall each business day. The route covers approximately eight miles along the perimeter of the facility and allows the ERM staff to monitor activities around the plant in addition to conducting sampling and obtaining flow, temperature and pH measurements. This level of attention to housekeeping issues is a necessary, but often overlooked portion of good pollution prevention program that was not seen at the other sites visited.[18]

C.6.2.3 <u>Corporate Record on Environmental Issues</u>

Historically, LFWC's most difficult compliance challenges have concerned air emissions. In 1991, the U.S. District Court ordered General Dynamics to bring its maskant and adhesive prime operations into compliance with the Texas State Implementation Plan (SIP). The company elected to eliminate the maskant process and to install an emissions control system for the adhesive prime operations.[19]

The facility has also had difficulty in meeting the Texas Air Control Board (TCAB) rules for volatile organic compound (VOC) emissions associated with surface coating of miscellaneous metal parts and products. In June 1993, the TCAB approved GD's Alternate Reasonably Available Control Technology (ARACT) proposal. After signature

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[18]On the day the author accompanied the plant representative on the route, we observed a construction contractor cleaning tools in one of the plant's outfalls and identified two drums of hazardous waste not placed in the proper storage location. Both problems were immediately corrected.

[19]Ejaz Baig, Investigator, Region 8, Texas Air Control Board, "State Implementation Plan Investigation at Lockheed Fort Worth Company," (Austin, TX: Texas Air Control Board, 29 July 1993) 5.

by the Governor of Texas, the ARACT was forwarded to the U.S. EPA as a site-specific revision to the State Implementation Plan (SIP). With approval of the ARACT, its site-specific requirements now apply in lieu of the "normal" TACB rules. In the ARACT, LFWC agreed to implement a variety of process controls to reduce VOC emissions.[20]

Yet another air emissions issue that LFWC faces involves its use ozone depleting chlorofluorocarbons (CFCs) for cleaning and degreasing. In the late 1980s, LFWC was the largest user of CFC-113 in the United States. Reducing this usage has been a major undertaking over the past several years.

In working to reduce its use of CFCs, LFWC has established a positive environmental reputation. In 1992, LFWC received four EPA Stratospheric Ozone Protection Awards for innovations and support of global efforts to eliminate the use of ozone depleting chemicals.[21] In addition, the company now represents the United States on the United Nations Environment Programme Technical Options Committee, which is chartered with identifying alternatives to ozone depleting chemicals.

In looking at LFWC's record across all compliance areas, the company has struggled to stay in compliance. Between November 1991 and October 1993, LFWC's facilities were inspected 26 times by environmental regulatory agencies. As a result of these inspections, LFWC had four notices of violation in 1993, but none resulted in fines.

In addition, the Air Force evaluated LFWC's environmental compliance three times. One of the Air Force evaluations, one evaluation was a one week long environmental audit conducted by a team of fourteen people. The audit produced no significant findings,[22] but

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[20]Ibid.

[21]Ibid.

[22]Significant finding -- is defined in the Air Force's Environmental Compliance Assessment and Management Program (ECAMP) as a finding that requires immediate action. It poses, or has a high likelihood of posing, a direct and immediate threat to human health or safety, the environment, or the installation mission. Some administrative issues can also be categorized as significant. For example, failure to ensure that hazardous waste is destined for a permitted facility, failure to report when required, and failure to meet a compliance schedule.

it did identify eight major and twenty minor findings. While any number greater than zero is undesirable, this result is very favorable in comparison to audits conducted at similar industrial facilities.

A summary of LFWC's TRI data from 1988 through 1992 is shown in Table C.5.[23] The figures shown represent total releases tracked at LFWC and include some releases that fall below the TRI reporting threshold.[24] The figures do not include quantities used for energy recovery, quantities recycled, or quantities treated.

LFWC's 1988 TRI baseline is 3,924,400 pounds of chemical releases.[25] For the most recent year available, 1992, LFWC reported total releases of 941,000 pounds. This represents a reduction of 76 percent from the 1988 baseline.

LFWC's 1988 data, shown in Table C.5, does not agree with information taken from the EPA's TRI data base, the Toxic Chemical Release Inventory System (TRIS). In January 1992, an EPA report titled, "Toxic Release Inventory Report for Government-Owned, Contractor-Operated Federal Facilities," was prepared by the Office of Federal Facilities Enforcement using the TRIS data base. The report lists total releases for U.S. Air Force Plant Number 4 (LFWC) in 1988 as 2,398,553 pounds.[26]

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[23]Lockheed Fort Worth Company, "Inventory of Reported Emissions and Off-Site Transfers," company report, (Fort Worth, TX: Lockheed Fort Worth Company, 7 July 1993) 1-4.

[24]Current EPA criteria require facilities that use more than 10,000 pounds of a TRI chemical per year to submit an EPA Form R on each chemical that exceeds the threshold.

[25]LFWC's TRI data is derived from several sources. Hazardous wastes are tracked using their manifests. Liquid wastes treated in the industrial waste plant are either metered or estimated. Volatile releases are estimated either from purchase records or from bar coded issues and turn-ins using a mass balance methodology. For example, since solvents do not become part of a product, the total annual purchase is assumed to be released. Quantities for the amount recycled and the amount disposed as hazardous waste are known. The unknown quantity is the amount released to the air. This quantity is estimated by subtracting the hazardous waste and the amount recycled from the annual purchase amount. The difference is assume to be the release to the air. VOC emissions from painting operations are estimated using bar code issue and turn-in records. In this case, the volatile content of each type of paint is used in the calculation.

[26]Office of Federal Facilities Enforcement, Office of Pollution Prevention, "Toxic Release Inventory Report for Government-Owned, Contractor-Operated Federal Facilities," (Washington D.C.: US Environmental Protection Agency, January 1992).

Bold Chemicals are part of the EPA 33/50 Program
(All Figures are Total Chemical Releases in Pounds)

Chemical	**1988**	**1989**	**1990**	**1991**	**1992**
Acetone	23,000	27,200	19,600	9,800	11,200
Ammonia	1,400	1,200	1,400	1,400	1,400
Barium Compounds	0	8,000	7,000	0	0
n-Butyl Alcohol	0	0	10,400	0	0
CFC 113	570,000	500,400	470,200	390,800	282,600
Chromium Compounds	29,600	30,200	29,800	28,200	57,600
Dichloromethane	46,800	30,000	21,200	23,200	18,200
Glycol Ethers	36,800	37,000	16,200	11,600	7,000
Hydrochloric Acid	2,800	2,800	2,800	2,000	0
Hydrofluoric Acid	6,800	1,400	1,400	1,400	1,000
Methyl Alcohol	6,500	13,600	2,000	3,400	4,200
Methyl Ethyl Ketone	218,600	197,600	103,600	98,000	36,000
Methyl Isobutyl Ketone	43,200	41,600	13,600	14,600	19,600
Nitric Acid	124,000	0	14,200	14,000	25,600
Sodium Hydroxide	0	14,400	0	0	0
Sodium Sulfate	1,500,000	0	0	0	0
Sulfuric Acid	1,600	1,600	1,600	1,600	1,400
Toluene	263,400	147,000	89,800	131,000	62,400
1,1,1 Trichloroethane	163,400	122,200	100,000	67,200	31,800
Trichloroethyene	664,000	590,000	620,200	371,000	302,000
Xylene	270,400	166,800	112,400	161,000	79,400
33/50 Program Releases	1,671,500	1,325,400	1,090,600	894,200	607,000
Total TRI Releases	3,924,400	1,933,000	1,637,400	1,330,200	94[illegible],400

Table C.5. LFWC Toxic Release Inventory (TRI) Reporting
From 1988 through 1992

In tracing the source of the differences with Mr. Plett[27] at LFWC, two errors were found in the EPA data base. First, LFWC's records show that a Form R was submitted for 1.5 million pounds of sodium sulfate releases to the city's publicly owned treatment works. The EPA data base shows no sodium sulfate releases. Second, LFWC's records show 38,000 pounds of fugitive air emissions for methyl ethyl ketone were reported. The

[27]David Plett, Senior Environmental Engineer, Lockheed Fort Worth Company, telephone conservation with author, 14 February 1994.

EPA data base shows only 3,800 pounds. In the first case, the Form R was probably lost or the data entered for another facility. The second error appears to be data entry error.

LFWC, along with the rest of Lockheed, is a voluntary participant in the EPA's 33/50 Program, which calls for reduction of the releases in seventeen che::icals by 33 percent by 1993, and 50 percent by 1995 based on a 1988 baseline. LFWC's 1988 baseline for EPA's 33/50 Program is 1,671,500 pounds. For 1992, LFWC reported 33/50 Program releases of 607,000 pounds. This is a 64 percent reduction compared to the goal of reducing releases of the program specific chemicals by 50 percent by 1995. The majority of the reductions have been achieved by replacing or eliminating volatile air emission from solvents and by reducing hazardous wastes. LFWC plans to achieve an 85 percent reduction by the end of 1995.[28]

Beginning with the TRI reports for 1990, a production index had to be included on each Form R TRI report. LFWC has used the number of F-16s delivered as the basis of its production index since 1990 as shown in Table C.6.[29]

Year	F-16 Deliveries	Forward Fuselages	Equiv. F-16s	Total	Index
1990	222	34	11.3	233.3	-----
1991	175	24	8.0	183.0	0.78
1992	107	24	8.0	115.0	0.63

Table C.6. LFWC Toxic Release Inventory Production Index

For 1992, the production index was 0.63, indicating that 68 fewer F-16s were delivered in 1992 than in 1991. Applying the index to the 1991 33/50 Program releases gives adjusted 1991 releases of 894,000(0.63) = 563,346 pounds. When compared to the

[28]Mckee and Evanoff, 180.

[29]The forward fuselages are produced at LFWC and shipped to several companies at assemble F-16s overseas under license. Each forward fuselage is counted as 1/3 of an F-16. The total number of F-16s is found by adding the F-16 delivered to the number of equivalent F-16s.

1992 releases of 607,000 pounds, the relative size of releases per aircraft actually increased slightly from 1991 to 1992.

Since the basis of the production index has remained constant since 1990, it is possible to calculate a composite production index covering 1990 through 1992. The resulting index is 0.63(0.78) = 0.49. Applying this to the 1990 33/50 Program releases gives adjusted releases of 0.49(1,090,600) = 534,394 pounds. Comparing this to the 1991 adjusted releases of 563,346 pounds and to the 1992 releases of 607,000 pounds, the production index indicates that total releases per aircraft produced have increased in each of the last two years.

If the production index is an accurate metric for adjusting releases to take production changes into account, LFWC's 33/50 Program release reductions can all be attributed to the falling production rate for the F-16. Given the many changes to production processes in the last several years aimed at reducing VOC emissions, this is unlikely. It is more likely that the index is a poor means of adjustment. The metric does not capture manufacturing parts, components, and assemblies that are sold as spare parts to keep existing planes flying. With over 3000 F-16s produced, the product support market is huge. Based on these facts, LFWC should identify one or more production indices that more accurately reflect changes in releases that occur as production levels change. In addition, as the production of new F-16s continues to wind down, the metric will become less and less reliable has the percentage of work done to support the after market continues to increase.

C.6.2.4 Implementation and Results

C.6.2.4.1 F-16 Program

Although the F-16 production contracts do not require any specific hazardous materials or pollution prevention actions, most of the core ERM and HMMPO activities

described above can be thought of as supporting the F-16 program since the F-16 is currently the only system in production.

In addition to the formal pollution prevention activities described above, LFWC and the Air Force also carryout many technical activities that have environmental and pollution prevention consequences. Two examples of technical activities that have important environmental implication are the F-16 Environmental/Hazardous Material Working Group and the F-16 Corrosion Prevention Advisory Board.

The F-16 Environmental/Hazardous Material Working Group was formed voluntarily by LFWC, Westinghouse Electric Corporation[30] (WEC), and the Air Force in October 1991 to discuss environmental issues and exchange technical data. Since 1991, the group has continued to met several times a year.

The F-16 Corrosion Prevention Advisory Board is established contractually and its membership is defined in the Corrosion Prevention and Control Plan. The board also serves as a forum for exchanging technical information and making recommendations to the F-16 program manager. The board reviews corrosion related issues including new finishing materials, factory process changes, and related environmental issues. At a recent meeting, well over half the items discussed over a two day period concerned the environment.[31] Of the 29 agenda items, twelve directly concerned environmental issues, and six others included environmental issues.[32]

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[30]Westinghouse manufactures the radar used in the F-16 under contract directly to the Air Force. The equipment is then provided to LFWC as government furnished equipment and installed during assembly. The Air Force also buys a few other types of electronic equipment directly, but most companies that supply parts and equipment for the F-16 have subcontracts directly with LFWC.

[31]Lockheed Fort Worth Company, Minutes of the 1993 F-16 Corrosion Technology Interchange Meeting held at Fort Worth, Texas, 2-3 November 1993, (Fort Worth, TX: Lockheed Fort Worth Company, 24 January 1994).

[32]The status of ODC elimination in the F-16 is an example of a direct environmental issue. The testing of a non-chromated corrosion inhibited sealant is an example of an item that only included environmental issues. At the meeting, LFWC presented the results of test procedures on the new sealant. Among the tests conducted was the toxic characterization leach procedure (TCLP) which is used to characterize hazardous waste. A number of other corrosion-related test results were also presented. The

C.6.2.4.2 <u>F-22 Program</u>

As a member of the F-22 contractor team, LFWC implements the F-22 Hazardous Material Program (HMP). The change in ownership from General Dynamics to Lockheed has not affected LFWC's obligations under the F-22 contract. Since the F-22 program is discussed in detail in the Lockheed Aeronautical Systems Company (LASC) case study, its purpose and scope will only be briefly summarized here. Following the summary, LFWC unique F-22 issues will be presented.

The F-22 Hazardous Materials Program (HMP) is described in the Hazardous Materials Program Plan (HMPP).[33] The program includes identification, evaluation, elimination, minimization, and mitigation tasks.[34] The HMPP states that it covers system design, manufacturing, operation, repair, maintenance, support, and disposal decisions affecting the Air Force. System design and manufacturing issues having no impact on the Air Force are addressed by company internal policies and applicable federal, state, and local regulations.

The HMPP describes the HMP at the Fort Worth Division[35] as:

> . . . a subset of the Division Hazardous Materials Management efforts. In order to implement the contractual requirements of the F-22 program, the division program has been expanded to include some of the F-22 needs while preserving

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work on finding a new sealant is being carried because chromates are targeted for reduction in the EPA 33/50 Program.

[33]Lockheed Aeronautical Systems Company, "F-22 Program Weapons System Hazardous Materials Program Plan," 2-2.

[34]The HMPP calls for the F-22 contractors to identify all hazardous materials considered for use on the weapon system. The evaluation task includes identification and assessment of the environmental, health, and safety requirements, including applicable standards, transportation, storage, uses of hazardous materials, disposal of hazardous wastes, and mishap procedure requirements. The plan states that hazardous materials and processes will be eliminated or minimized where practical from the air vehicle, training system, and support system. If hazardous materials cannot be eliminated, by design or substitution, they are to be mitigated as judged appropriate by the Integrated Product Team (IPT).

[35]What is now the Lockheed Fort Worth Company (LFWC) was know as the Fort Worth Division while it was part of General Dynamics Corporation.

the established Division Hazardous Materials Management Program responsibilities and procedures. [36]

The relationship between the F-22 Hazardous Materials Program and the LFWC program is shown in Figure C.2.[37]

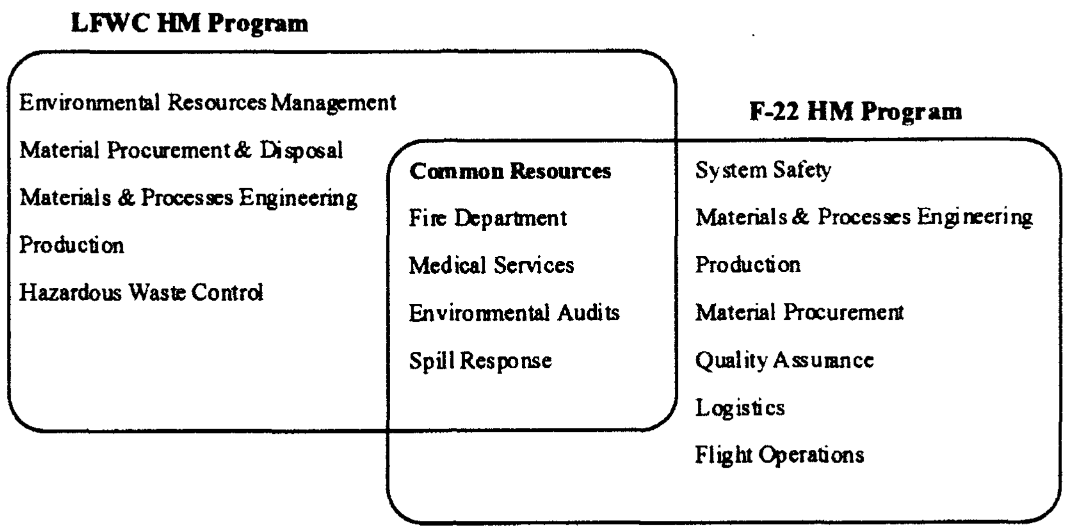

Figure C.2. LFWC F22 Hazardous Materials Program Unique Support

Note that Environmental Resources Management (ERM) is not included within the F-22 program. This was a critical decision. Instead of adopting the goal-driven pollution prevention management structure as ERM is applying to the core LFWC program, the F-22 program adopted the identification-evaluation process developed at LASC. The process is shown in Figure C.3[38] and is named after its first two steps. A key difference between the core LFWC program the F-22's Hazardous Materials Program (HMP) is the latter's lack of goals and metrics.

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[36]Lockheed Aeronautical Systems Company, "F-22 Program Weapons System Hazardous Materials Program Plan," C-3.

[37]Ibid., C-7.

[38]Arline Denny, "F-22 Hazardous Materials Program," presentation made at the 8th Annual Aerospace Material Management Conference, Chandler, AZ, 26-28 October 1993, (Marietta, GA: Lockheed Aeronautical Systems Company, 1993), 7.

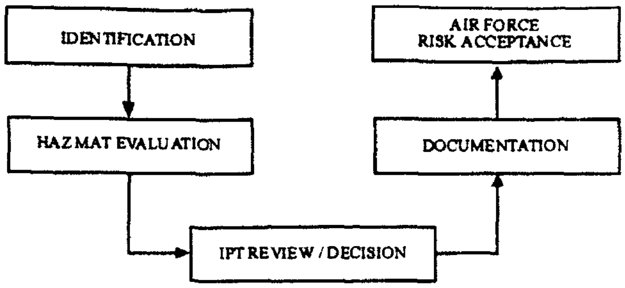

Figure C.3. F-22 Program - Material Review Process

In looking at the differences in how LASC and LFWC implement the procss, the most import difference concerns how the identification and evaluations steps are carried out. At LASC, the identification and evaluation steps are accomplished by a Hazardous Materials Review Board (HMRB).

The HMRB concept originated at LASC, but LFWC elected not to adopt the formal HMBR structure. Instead, LFWC conducts its hazardous material reviews using a less formal process.

> The IPT managers, M&P[39] participants, Occupational Health, Environmental Resource Management (ERM), Production, Material Procurement, Waste Management, and Environmental Audits will serve the F-22 Hazardous Materials Review Board function for General Dynamics.[40]

The LFWC hazardous materials review process, like the LASC process, examines each material to see if any of the material's constituents are on company's or the Air Force's target list for reduction or elimination. In addition, LFWC's process includes a detailed review of occupational health and environmental regulatory requirements, but it lacks the formal qualitative risk evaluation conducted at LASC. As a result, the review

[39]M&P means Materials and Processes

[40]Lockheed Aeronautical Systems Company, "F-22 Program Weapons System Hazardous Materials Program Plan," C-4.

process at LFWC is more focused on immediate environmental, industrial hygiene, and safety issues.[41]

As at LASC, once a material is approved by the HMMPO, LFWC does not have a systematic process for carrying out the program's pollution prevention objectives for the operation, repair, maintenance, and disposal phases of the program. The existing ERM pollution prevention program will address manufacturing, but this does not always address the issues that will be encountered once the aircraft leaves the factory. This is the greatest weakness in an otherwise outstanding pollution prevention program.

C.6.2.4.2 Environmental Metrics

LFWC uses the most extensive set of environmental metrics among the four companies visited. The ERM staff tracks sixteen metrics monthly, quarterly, and annually. The metrics are shown in Table C.7.

Using the metrics, LFWC has been able to show substantial progress in its pollution prevention efforts. As of the end of 1992, LFWC achieved the following progress:[42]

100% Reduction in PCB devices since 1984
95% Reduction in ozone depleting compound use since 1987
80% Reduction in effluent heavy metal discharges since 1987
80% Reduction in TRI chemical off-site transfers since 1987
75% Reduction in hazardous waste since 1984
66% Removal/replacement of underground tanks since 1984
64% Reduction in reported air emissions since 1987
47% Recycling of non-hazardous industrial solid waste in 1992
11% Reduction in non-hazardous industrial solid waste since 1991

One area where LFWC has not managed to excel is changing the cost accounting system to better track environmental costs to production centers. This is a common

[41]Examples of issues include consideration: of whether complete material safety data sheet (MSDS) information is available; requirements for eye or face protection, respiratory protection, and skin protection; if the material will produce a hazardous waste; if provisions of TASC apply; etc.

[42]Mckee and Evanoff, 181.

problem to all military programs since the government has not structure it accounting rules to enable industry to collect cost accounting information at the desired level of detail.

#	Major Area	Metric
1.	Hazardous Waste	Tons
2.	Wastewater Contaminants	Pounds of Heavy Metals
3.	Air Emissions	Tons
4.	PCB Devises	Number of Devises
5.	Ozone Depleting Chemical Use	Tons
6.	Underground Tank Removal/Replacement	Number of Tanks
7.	EPA 33/50 Program Transfers	Tons
8.	TRI Report Transfers	Tons
9.	Non-Hazardous Industrial Solid Waste	Tons Disposed
10.	Non-Hazardous Industrial Solid Waste Recycling	Tons Recycled
11.	Annual Off-Site Disposal Facility Audits	Number of Facility Audits
12.	Chemical Spill Prevention Measures	Number of Measures
13.	Unresolved Notices of Violation	Number of Open Notices
14.	Air Force Environmental Audit Findings	Number of Open Findings
15.	Awareness / Information Tools	Number of New Tools
16.	Environmental Training	Number of People Trained

Table C.7. LFWC Environmental Metrics

C.6.2.4.3 Management of Pollution Prevention Objectives

Management of LASC's core pollution prevention objectives is being carried out by the Manager, Environmental Resources Management (ERM). Management of the hazardous materials management effort on the F-22 is carried out within the program's management structure by the F-22 hazardous materials single point of contact.

Integration of the efforts occur as part of the Hazardous Material Management Program Office (HMMPO). Details on the HMMPO are presented in section C.6.3.1 of the case study.

As at LASC, the F-22 program is managed using an integrated product development organization. Within the F-22 program, there is a hazardous materials manager, but there is no one charged with a broader set of environmental responsibilities and the core functional staffs have little access or power. On the F-22, this results in a minimal role for the Environmental Resources Management (ERM) staff. In addition, informal environmental input into the program is further restricted by the off-site location of the F-22 design team.[43]

In this structure, the Materials and Processes Technology staff perform the primary environmental role which is to provide technical input to the IPTs. Fortunately, the Materials and Processes (M&P) Technology staff have been deeply involved in the pollution prevention program for many years. This scope and depth of the technical expertise available within M&P only becomes evident when one looks at their contributions to solving LFWC's technical problems. An indication of the range of technical skills available on the M&P staff can be seen by looking at the M&P organizational chart in Figure C.4.

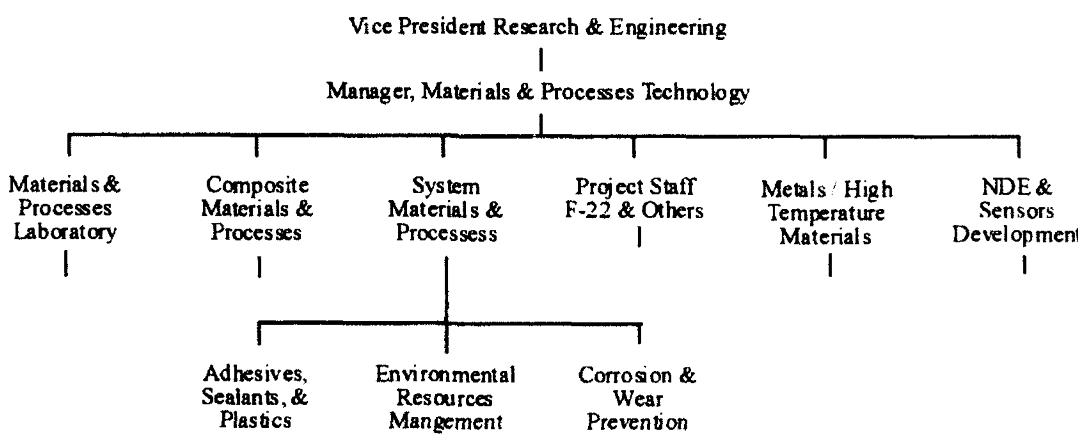

Figure C.4. Partial Materials & Processes Technology Organization Chart

[43]In other respects the off-site location is a benefit, minimizing the "interference" in the program.

The Environmental Resources Management (ERM) staff shown in Figure C.4 in the Materials and Processes Technology (M&P) organization is the a separate function from the core environmental staff with the same name that is shown in Figure C.1.

The M&P ERM staff consists of six scientists and engineers that work the technical portion of hazardous materials and other environmental issues. They get additional technical help from the technical specialists in the other M&P specialties. Drawing on this talent, LFWC has developed a host of new materials and processes that reduce the use of hazardous materials and reduce emissions.[44]

C.6.2.4.4 Pollution Prevention and the National Environmental Policy Act (NEPA)

There is no evidence that any of the information gathered over the years and contained in several dozen NEPA documents that supported F-16 beddowns at Air Force installations has been provided to LFWC to promote pollution prevention in the F-16 production program. This is a procedural issue that the Air Force should correct.

There is a similar lack of information from the F-22's environmental impact documents. While no beddowns have occurred for the F-22, the program office did produce an environmental assessment (EA) in April 1991 to support DoD's decision to proceed to engineering and manufacturing development (EMD). The main issues discussed in the EA were the impacts of the flight test program at Edwards, Holloman, Nellis, and Eglin AFBs. Manufacturing impacts on air and water quality were judged to be small, but no evidence was provided to support the claim. The EA also described the F-22's hazardous materials program for reducing hazardous material use. In addition, the EA contained a preliminary listing of hazardous materials that would be used in the system, but there was no indication of which materials would be used in the greatest quantities, which were the most toxic, or which would cause the greatest impacts. No

[44]Stephen P. Evanoff, "Hazardous Waste Reduction in the Aerospace Industry," Chemical Engineering Progress, (April 1990): 52-61.

specific data on manufacturing processes or pollution prevention options for reducing releases were presented. These are areas the EA could have included that would have provided meaningful input to the F-22's designers.

C.6.3 Implementation Contextual Factors

The seven factors discussed in this section are commonly cited in the implementation literature as being important for understanding an implementation process. Observations concerning the impact of each factor on the pollution prevention implementation at LFWC are presented below. The observations are relative to LASC's implementation of its internal pollution prevention policies as well as government requirements.

C.6.3.1 Organizational Structure and Relationships

The Hazardous Materials Management Program Office (HMMPO) is an important organization for implementing pollution prevention at LFWC. It structure is shown in Figure C.5.

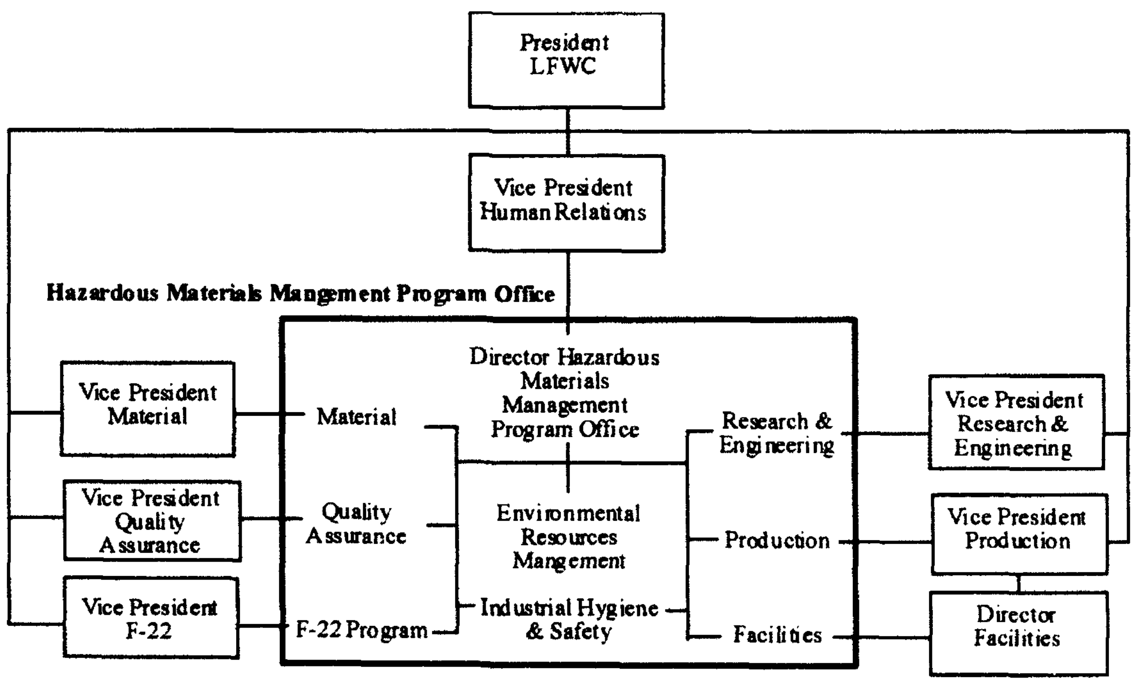

Figure C.5. Hazardous Materials Management Program Office (HMMPO)

The HMMPO meets weekly and serves to coordinate policy and actions in the plant and, to a lesser degree, on the F-22 program. The is better described as a standing environmental working group, but it can also be viewed as an environmental integrated product team.

For the F-16 program, the HMMPO is directly involved in every aspect of the pollution prevention from ordering and storing materials, to developing new processes, to disposing of wastes. The structure works well because all the major functions are represented within the HMMPO and the senior management is committed to making it work.

On the F-22 program the role of the HMMPO is less clear. The F-22 is a product oriented development team and the HMMPO is outside the program. The HMMPO uses a goal-oriented management style,[45] but the F-22's hazardous materials program is process oriented. One potentially important role for the HMMPO is reviewing new materials proposed for use on the F-22 that are not already used on the F-16. So far, however, this has been a small role since less than five new materials have been proposed for LFWC's portion of the F-22. Thus, HMMPO has had a much smaller role in the development of the F-22 than the Hazardous Material Review Board (HMRB) at Lockheed Aeronautical Systems Company (LASC).

C.6.3.2 Goal Structure

The core pollution prevention program at LFWC is implemented using a process similar to the waste minimization assessment procedure recommended in the U.S. EPA's Waste Minimization Opportunity Assessment Manual.[46] Figure C.6 shows the EPA waste minimization process along with a modified process used at LFWC.

[45] See section E.6.3.2 for an explanation of the goal-oriented process.

[46] Hazardous Waste Engineering Research Laboratory, Waste Minimization Opportunity Assessment Manual, (Cincinnati, OH: US Environmental Protection Agency, July 1988), 4, EPA/625/7-88/003.

Both processes feature a repeating assessment-analysis-implementation loop. The key difference between the processes is the explicit management loop shown on the left side of the LFWC process. In the LFWC process, program evaluation and goal setting are also continuing processes that are driven by tracking metrics that assess progress.

The goal structure at LFWC ranges from general principals to specific quantitative targets. At the top of environmental goal structure is LFWC's ERM Vision:

> Zero impact to the environment is achieved through a caring partnership of employees, community, suppliers, and customers. We are the leader in ERM and minimize risk to our community and employees.[47]

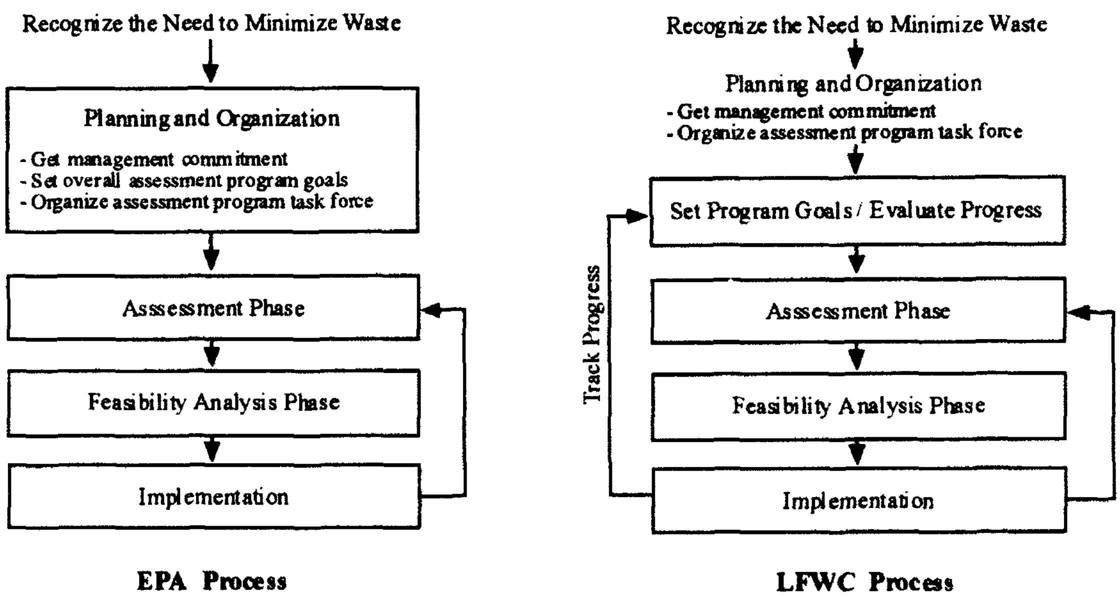

Figure C.6. U.S. EPA Waste Minimization Process &
LFWC Pollution Prevention Process

[47]Stephen P. Evanoff, Manager, Environmental Resources Management, presentation materials provided in interview by author, 27 October 1993, "Lockheed Fort Worth Company Environmental Resources Management (ERM)," Forth Worth, TX.

Just below the ERM Vision in the goal hierarchy is the ERM Philosophy:

1. Pollution prevention and toxics use reduction are the foundation for our program and the focus of our projects.
2. Environmental administration and policy issues must be consolidated into a single function and must have top management support and visibility.
3. Environmental responsibility and knowledge for day-to-day operations must be driven to the working levels in all functions.
4. Given the proper training and tools, people will do the right thing!
5. We are a service organization; the manufacturing organizations and the USAF are our principal customers.[48]

Next in the hierarchy are the environmental program strategic goals:

1. Achieve zero discharge
2. Assure continued compliance
3. Maintain proactive communications
4. Develop a comprehensive hazardous materials management system
5. Implement risk management.[49]

Below the strategic goals are annual goals and metrics. For 1993, ERM had six "umbrella" goals. For example, the first umbrella goal for 1993 was to achieve the individual Zero Discharge goals. This umbrella goal, in turn, leads to fourteen specific quantitative goals and metrics for 1993 covering each Zero Discharge category. The strategic goal for assuring continued compliance resulted in annual goals to audit 100 percent of off-site hazardous waste treatment and disposal facilities and to achieve and maintain a status of zero unresolved notices of violation.

The goal setting process used at LFWC was unique among the companies studied. Most companies have at least some quantitative environmental goals and the target values are selected more or less arbitrarily. An example of this approach is the EPA's 33/50 program. At LFWC, most goals were not set arbitrarily. Instead, goals were set only after examining the technically feasible and cost effective potential projects that could be undertaken.

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[48]Ibid.

[49]Ibid.

Key factors in LFWC's success in using this approach include using the HMMPO to develop, coordinate, and implement action plans, assigning responsibility for tracking each goal to a member of the ERM staff, and selecting metrics that are meaningful, yet do not require too much time or effort to update and maintain.

In addition, using this approach focuses communications with top management. The status of the environmental program is readily provided and the results of management's decisions on resource allocation to the ERM program are readily identifiable.

Within the F-22 program, the identification-evaluation hazardous material process shown in Figure C.3 is used.

C.6.3.3 Knowledge Base

LFWC has a strong knowledge base of scientists, engineers, and managers. The technical ability of the technical staff is well documented. They have developed many new processes, materials, and applications over the past several years in their efforts to address environmental issues. Examples of this includes development of new alkaline degreasing processes and regeneration procedures, new wipe solvents, use of high-solids low-VOC paints, implementation of ion-vapor deposited aluminum, and development of a new paint gun cleaning solvent.[50] These engineering innovations together with the implementation of numerous waste reduction projects demonstrates the depth of the knowledge base.

C.6.3.4 Resources.

Both people and funding for pollution prevention are difficult to obtain, but ERM has done relatively well considering the overall health of the industry and the uncertainties facing the future of the F-16, the only current production program at the plant.

[50]Earl W. Turns, Project Engineer, Lockheed Fort Worth Company, presentation at the 8th Annual Aerospace Hazardous Materials Management Conference held at Chandler, AZ, 27 October 1993.

As in the rest of the aerospace industry, LFWC has been reducing its work force. As recently as 1991, LFWC employed 32,000 people. By the end of 1994, employment will probably fall to around 10,000, a reduction of almost 70 percent. Of this total, only about 1200 are employed on the F-22 program. This has made it impossible to expand the ERM staff, to meet the demands of the 1990 Clean Air Act Amendments and expanding demands for pollution prevention activities. On the other hand, no one in ERM has been let go despite the massive reductions.

Since the major facilities at LFWC are part of Air Force Plant (AFP) 4, the government must funds all capital projects under the terms of the facility contract between the Air Force and Lockheed. This means LFWC must deal with a lengthy multi-year programming and budgeting system that in recent years has only approved environmental projects that are critical for compliance.[51] Thus, pollution prevention efforts that require facility modifications are nearly impossible to accomplish.

The government does not purchase plant equipment, however. Thus, most changes to production processes must either be funded directly by the F-16 program office or be done with company funds and charged to overhead. With the end of F-16 production potentially in sight, convincing management to invest company funds has been difficult, but not impossible. ERM's metrics clearly show they have been successful in obtaining resources. Since 1984, over 35 Zero Discharge projects have been implemented.[52] Interviews with the LFWC staff indicate that they believe there is more support for funding environmental costs by Lockheed than was the case at General Dynamics.

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[51]There are many active Air Force funded compliance projects at AFP-4. For example, the Central System for Control of VOC Emissions, a $2.7 million effort, is nearly complete. A $600,000 closed loop cooling system will be completed in 1994. A $3.0 million project to replace vapor degreasers will also be completed in 1994. A multi-year effort to replace and upgrade underground tanks is continuing. A $1.2 million design effort on a new industrial waste treatment facility is in progress. There are also a number of smaller compliance projects in progress. In all, there are over 15 active projects representing approximately $38 million in construction costs.

[52]McKee and Evanoff, 180.

Given, LFWC's goal-oriented approach to pollution prevention, they should continue to compete well for limited company resources.

C.6.3.5 Dispositions

The overall disposition of LFWC employees on environmental issues was observed during each interview and was evaluated using a questionnaire during the site visit. Results of the questionnaire are presented in detail in Appendix F. A summary of the survey results is presented below.

The questionnaire consisted of a total of 27 questions and contained questions on six general topics: environmental behavior, environmentalism, environmental concerns, pollution prevention, and environmental performance. Twenty of the 27 questions were taken from national surveys on the environment.

At LFWC, the respondents answered seven of twenty questions differently than people in a national random sample. In this study, finding five or more different answers from the national data is assumed to be an indication that employees have a different disposition toward the environment than the national average. Note that there are no "right" or "wrong" answers to the questions and that different is relative to the question asked--different behaviors, different concerns, etc. The 34 responses obtained at LFWC represent the smallest sample collected at any of the facilities. In addition, the sample contains more responses from non-professional employees than at the other companies studied, although 68 percent identified themselves as professional or management. As a result of evaluating the survey data[53] some general conclusions can be drawn.

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[53]Note that there are three sources of potential bias with the survey results. First, the data collected at LFWC does not represent a random sample. Second, the questionnaires were distributed in the work place while the national data are from telephone surveys. This biases the definition of "environment," since environment is not defined (it may mean the local environment, national environmental, global environment, etc.). On the questionnaire, respondents appear to assume that several questions are referring to the work place environment. This would not occur in the telephone survey. Finally, there is a bias toward professional and management employees among the respondents. At LFWC, 68 percent of the respondents identified themselves as managers, engineers, or other professionals.

The employees tend to believe that the condition of the environment is getting better. Therefore, they are less worried aoout the environment than people nationally. They also believe that, in general, business, industry, and the Government all spend too much time worrying about the environment, but that their company is not enough worried.

The respondents at LFWC considered themselves to be environmentalists as frequently as people in the national survey, but fewer considered themselves to be a strong environmentalist. In addition, they were willing to lose jobs in their community in order to protect the environment. LFWC respondents were the only group in this study that did not differ from the national data on this point. An important issue at a facility suffering a stead decline in overall employment. In addition, the respondents do volunteer work for environmental groups, contribute to environmental groups, and boycott products in similar percentages to the national survey. They are more likely to voluntarily participate in recycling programs. While they believe that environmental requirements can be set too high, they are willing to pay higher taxes to protect the environment. Finally, and most importantly, almost 90 percent believe that the company strongly supports efforts to prevent pollution and that more time should be spent on environmental issues.

Summarizing the survey data, the employees at LFWC display different views than those found in the national surveys. On balance, they have a more positive outlook on the condition of the environment, they believe that environmental can be set too high, but they are will to pay more taxes to protect the environment. In addition, almost 80 percent believe that project quality includes reducing pollution. This is the highest percentage of respondents at any company linking quality and pollution prevention. In addition, there is strong support for the company's pollution prevention efforts and a desire to do more.

In conclusion, based on the survey results and the interviews three important point can be made: 1) the employees at LFWC understand the pollution prevention policies, 2) they accept the policy, or are neutral toward the policy, and 3) they have different views on the environment than found in national samples, but the difference do not include

strong negative attitudes about environmental issues. This supports the research assumption that LFWC's employees do not display any wide spread negative disposition toward pollution prevention activities that would interfere with implementation of the company's policies.

C.6.3.6 Decision Making and Management Procedures

Decision making processes in the environmental area are impacted by two features of the management system at LFWC: 1) using a team-oriented approach for solving problems, and 2) using a goal-oriented management and control system. Together, these management philosophies have produced a highly integrated and focused environmental program.

The team-oriented approach is evident in both the Hazardous Materials Management Program Office (HMMPO) and in the F-22 integrated product teams. The results of the using a team approach are evident in the large number of people from different functional areas throughout the plant that are involved in environmental issues. This should result in timely and well-balanced decisions.

Not all employees believe this however. There is a strong minority view that believes the IPT process is too bureaucratic, not goal orientated, and too slow in making decisions. In addition, they feel that the amount of work needed to develop the F-22 will expand to fill the time available. In this case, the ten year EMD schedule. Given these attitudes, management needs to do a better job in implementing integrated product development. The staff has heard how the process is designed to work, now management must deliver.

In addition to being team oriented, the environmental program is also goal oriented. The impact of the goal-oriented approach has been to keep the company's pollution prevention efforts in front of management and focused on the "right" issues. In this area

the interviewees seems to be general agreement that without the pressure associated with meeting goals and deadlines, the company would being making a lot less progress.

C.6.3.7 Communications

Everyone encountered during the site visit had something to say about how the environmental program. This is a sure sign that communications on environmental issues is strong. Strong communications is not at accident, but the result dynamic leadership and a commitment to employee environmental awareness and training programs.

The results of ERM's employee awareness and training efforts can be seen throughout the plant. There are frequent environmental articles in the weekly plant newsletter, posters are displayed everywhere, metrics are displayed for all to see, and a variety of training classes are held on a regular basis. ERM produces video tapes, quick reference guides, and leaflets in addition to posters. As a result of these efforts, the employee awareness program at LFWC is the most comprehensive seen at any of the sites visited in this research.

> Environmental awareness training consists of working sessions and discussions in the manufacturing areas with the help of video tapes, posters, and brochures to keep all employees informed and involved. . .
> . . . It is standard practice for representatives of the ERM department to solicit opinions about P2 from employees on the shop floor. Monthly pizza lunches are held to foster communications and recognition for the P2 program. The Vice President of Human Relations presents "ERMinence Awards" to individuals for their ERM Program initiatives and innovations. The only barrier to awards are the union rules which do not allow significant or monetary awards to individual employees.[54]

A good example of the strength of the employee support that ERM has generated can be seen it LFWC's implementation of its environmentally complaint wipe-solvent

[54]A. S. Kallus, Mary Jensen, John Giesen and Lennard Blanton, "Pollution Prevention Case Study Lockheed Fort Work Company," in the Proceedings of the Fifth Annual Environmental Management and Technology Conference/Southwest held in Dallas, Texas, 28-30 September 1993, (Glen Ellyn, IL: Advanstar Expositions, 1993) 478.

program. In addition to developing a set of low-VOC emission wipe solvents, LFWC discovered that the greatest emission in using wipe solvents normally comes from the wet rags following cleaning.

> Even when placed in standard rag cans they continue to emit VOCs. The lower the vapor pressure, the slower this emission, but even low vapor pressure solvents eventually release all of the VOC's to the atmosphere. The approach taken was to place the wet rags in specially selected vapor-proof bags which eliminates the emission to the atmosphere.[55]

The bags are then collected and sent to an incinerator. The challenges in implementing the program were to get the workers to use the right solvent for each application; to put a minimum amount of solvent on a rag; and then after use, to put the wet rag into a special aluminized-plastic bag immediately after use and to then seal the bag. Making this work took an extensive education and awareness effort. The fact that the program is working, is a clear indication of the company's employee awareness is working.

C.7 Annex to Appendix C -- Text of Contract Pollution Prevention Requirements

Paragraph 3.4.1.10 of the F-22 Statement of Work, Contract F33657-91-C-0006, defines the hazardous materials program requirements.

> **Hazardous Materials Program.** (WBS 41AO). The contractor shall develop, maintain, and update a Hazardous Materials Program (HMP) as defined in the approved Hazardous Materials Program Plan (HMPP) and described in the HMP narrative Integrated Master Plan. The contractor shall integrate the HMP into all aspects of the FSD program, including those of associates, subcontractors and suppliers, focusing on elimination of hazardous materials, where possible, or mitigation of consequences as appropriate. The contractor shall coordinate the HMP with the System Safety Program Plan and appropriate specialists including toxicologist, chemists, materials and processes analyses, environmental impact and occupational safety/health personnel. The Contractor HMP shall address the entire life cycle of the weapon system to ensure optimization and balance between design

[55]Henry J. Weltman and Tony L. Phillips, "Environmentally Compliant Wipe-Solvent Development," in the Proceedings of the Society of Automotive Engineers meeting held in Anaheim, California, 5-8 October 1992, (Warrendale, PA: Society of Automotive Engineers, 1992) 8.

> parameters and hazardous materials constraints. The Contractor HMP shall comply with regulatory requirements (AFOSH/OSHA) to include transportation, storage, use and disposal of hazardous materials and waste identified as part of the weapon system or its support requirements. The contractor HMP shall include tasks that address identification, evaluation and use of hazardous materials, the disposal of hazardous waste, mishap procedures, and how this will be reported to the Government. The Contractor shall develop and maintain a listing of all hazardous materials (including the amounts and exposure limits) used/produced during this program and prepare Hazardous Materials Analyses Reports as required by the CDRL. The Contractor shall summarize results of analyses and trade studies and their impact on design for inclusion in the Air Vehicle/System/Subsystem Environmental Impact Report, and provide hazardous materials inputs to the Weapon System Occupational Safety and Health Assessment. Reporting requirements shall be in accordance with the CDRL (OT-90-34206, OT-90-34208).[56]

The work breakdown structure (WBS) code, listed at the beginning of the paragraph, identifies the tasking in the program management system. The integrated master plan (IMP) narrative is a contractor prepared document that is used to define and track program requirements. The codes listed at the end of each paragraph, such as OT-90-34206, are data item descriptions (DIDs) that provide information to the contractor on how the information required by the SOW is to be provided to Government. Definitions for the DIDs are individually specified in another portion of the contract using one or more copies of Department of Defense Form 1423-1. For example, OT-90-34206, provides information on the Hazardous Materials Program Plan. The form specifies the time allowed for the contractor to develop the plan, and for the Government to review the contractor's submittal. In addition, the DID defines the plan's format, the number of copies to be submitted, and identifies the offices to receive a copy.

[56]Lockheed Aeronautical Systems Company, "F-22 FSD Statement of Work," 33-34.

APPENDIX D

CASE STUDY AT MCDONNELL DOUGLAS AEROSPACE - EAST

St. Louis, Missouri

F-15 Eagle, F/A-18 Hornet, AV-8B Harrier II, T-45 Goshawk, A/F-X

D.1 Introduction

McDonnell Douglas Corporation (MDC) is a major supplier of military and commercial aircraft as well as missile, space and electronic systems. McDonnell Douglas Aerospace - East (MDA-E) includes all of MDC's St. Louis area operations and is responsible for most of MDC's military programs. This includes tactical aircraft, helicopters, and missile systems. The only major military aircraft program not managed by MDA-E is the California-based Air Force C-17 Globemaster III military transport program.

D.2 Case Study Organization

The body of the case study is organized into six major sections: 1) Program Overview, where general background information is provided for each program included in the study; 2) Corporate Background, where information on the parent corporation is presented; 3) Data Gathering, which provides information on how and when the study data were collected; 4) Results and Analysis, where the details of the case are presented; 5) Summary; and 6) Text of Contract Pollution Prevention Requirements.

The heart of the case study, the Results and Analysis section, begins with a presentation of the relevant program contract requirements and corporate policies. The section continues with the organizational setting, features of the pollution prevention

program, the corporate environmental record, and pollution prevention results. The final portion of the section includes a separate analysis on each of seven different implementation factors.

D.3 Program Overview

Six MDA-E aircraft programs are reviewed in this case study: 1) the F-15 Eagle, 2) the F/A-18C/D Hornet, 3) the F/A-18E/F Hornet, 4) the AV-8B Harrier II, 5) the T-45 Goshawk, and 6) the A/F-X. The status of each program is summarized in Table D.1.

Aircraft	Acquisition Phase	Contract Pollution Prevention Requirements
F-15	Production	None
F/A-18C/D	Production	None
F/A-18E/F	Engineering & Manufacturing Development	Evaluate materials unique to new the E/F models
AV-8B	Production	None
T-45	Production	Avoid Specific Chemicals & Extensive Analysis
A/F-X	Canceled	Extensive Hazardous Material Program

Table D.1. Program Status Summary

D.3.1 F-15 Eagle

The Air Force selected MDC to develop the F-15 Eagle air superiority fighter in December 1968 and the Eagle's first flight occurred in 1972. Through 1993, MDC has delivered[1] over 1200 F-15s to the air forces of the United States, Israel, and Saudi Arabia.

The F-15 is still the Air Force's primary air-superiority fighter. During Operation Desert Storm the F-15 destroyed thirty-six of the thirty-nine fighters Iraq lost in air combat. While the F-15 was originally designed primarily as an air superiority fighter, the current production version, the F-15E, is a dual-role air-to-air and air-to-ground system.

[1]Mitsubishi Heavy Industries produces the F-15J under license for Japan's air force.

Air Force orders for the F-15E will be completed with a final aircraft delivery in mid-1994, but production will be extended into at least 1998 by an order for 72 additional aircraft by Saudi Arabia.

Existing Air Force contracts for the F-15 have no provisions for pollution prevention. Under the terms of the agreement to sell additional F-15s to Saudi Arabia, the actual production contracts are negotiated and managed by the USAF's F-15 Program Office. At the time of this writing, the program office was exploring what pollution prevention provisions would be appropriate to include in the production contract for the additional Saudi aircraft.

D.3.2 F/A-18 Hornet and F/A-18E/F

The F/A-18 is a twin-engine multi-mission strike fighter[2] that is designed to carry out both air-to-air and air-to-ground missions. The Navy awarded McDonnell Douglas a contract to begin development of the F/A-18 on 22 January 1976.[3] Under a teaming arrangement, Northrop is responsible for the center and aft fuselage, which represents about 40% of each aircraft.[4] More than 1100 F/A-18s have been delivered worldwide.[5]

In 1992, the Navy awarded MDC a $3.7 billion contract to begin Engineering and Manufacturing Development (EMD) of a major upgrade to the Hornet, called the

[2]The F/A-18 has a wing span of 37.5 feet, is 56 feet long and its tail is 15.3 feet high. The Hornet has a maximum take-off weight of approximately 47,000 pounds. By comparison, the larger F-15C has a wing span of 42.8 feet, is 63.8 feet long, stands 18.7 feet high, and has a maximum take-off weight of 62,000 pounds.

[3]The program traces its beginning to Congressional action in August 1974 directing the Navy to investigate the Air Force's YF-16 and YF-17 prototypes to fill its need for a low-cost, lightweight, multi-mission fighter. In response, McDonnell Douglas teamed up Northrop, builder of the YF-17, to propose a new aircraft derived from the YF-17 to meet the Navy's requirements.

[4]Other principal subcontractors for the F/A-18 include the General Electric Company, which produces the F404-GE-402 engine; and Hughes Aircraft Company, manufacturer of the Hornet's APG-65 radar.

[5]The Hornet is currently flown by the United States Navy and Marine Corps and the air forces of Canada, Australia, Spain, and Kuwait. In addition, Finland, Malaysia, and Switzerland have ordered the F/A-18.

F/A-18E/F.[6] The contract calls for a 7.5 year development effort that includes producing seven flight test aircraft and three ground test aircraft.

The logistics support specification requires MDC to identify and evaluate all E/F unique hazardous materials (materials not used on current versions of the aircraft) that will be used in manufacturing or support of the aircraft. The text of the relevant portion of the contract is included at the end of the case study.

D.3.3 AV-8B Harrier II

MDC, British Aerospace, and Rolls-Royce proposed the AV-8B as a successor to the AV-8A to meet Marine Corps requirements in the mid-1970s for a short takeoff, vertical-landing aircraft that could be forward based. The Marine's called for an aircraft with nearly double the existing AV-8A's payload and range. The AV-8B's first flight occurred in 1978 and the first production aircraft was delivered in 1983. Deliveries of the radar-equipped, night-attack Harrier II began in 1989. MDA-E has delivered approximately 270 aircraft over the life of the program. New orders for the Harrier II in late 1992 and early 1993 by Italy and Spain will keep the AV-8B in production into the late 1990s.

MDC's current contracts for the AV-8B do not require any pollution prevention planning or other related activities.

D.3.4 T-45 Goshawk

The T-45 Goshawk[7] is a modified version of the British Aerospace-build Hawk designed to fill the Navy's requirements for an advance flight-training aircraft. MDC began the engineering and manufacturing development effort to convert the land-base

[6]The upgraded aircraft will have a 34-inch fuselage extension allowing a 33% increase in internal fuel capacity, a larger wing with an additional 100 square feet of surface area for improved flight characteristics, updated engines with 35% more thrust, and numerous other improvements.

[7]The T-45 has a wingspan of 39.3 feet, a tail height of 14 feet, and its gross weight is approximately 13,000 pounds.

Hawk in 1984. The resulting Goshawk has been modified for aircraft carrier operations by strengthening the landing gear and adding an arresting hook and catapult launch fittings.

MDC and British Aerospace share production of the T-45. British Aerospace produces the aft fuselage and wing while MDC builds the forward fuselage and performs final assembly. Production deliveries began in 1992 and current Navy plans call for building a total of 268 aircraft through 2003. Twenty-nine aircraft have been delivered, approximately 10 percent of the planned fleet.

Unlike the other military aircraft MDA-E produces, the company is also under contract to provide a wide range of on-going logistical support, including aircraft maintenance, at each T-45 operating location.

The current T-45 contract requires MDA-E to undertake the most extensive pollution prevention activities of any DoD weapons program reviewed in this study. The Navy specifically tasked MDA-E in the integrated logistics support detail specification to evaluate the use of ozone depleters, high VOC topcoats, methylene chloride, and cadmium plating; to identify operations and maintenance tasks that require the use of hazardous materials; and for MDA-E to document environmental impact data including all hazardous material uses and hazardous wastes produced.

D.3.5 A/F-X

In December 1991, MDC was awarded a contract[8] to explore a "clean-sheet" design for the A/F-X, a next-generation carrier-based multi-mission aircraft, along with Vought Aircraft. The A/F-X program was canceled by DoD in 1993, but during its brief life, MDA-E expended considerable effort studying how to incorporate hazardous material use reduction and pollution prevention into the development program.

[8]The A/F-X effort began in the wake of the A-12 program cancellation when in January 1991, the Navy notified MDC and General Dynamics (joint prime contractors) that it was terminating the team's contract for development and initial production of the A-12.

D.4 Corporate Background

MDC is a major aerospace corporation with a strong presence in both the military and the commercial market segments. Since 1987, MDC has been the Department of Defense's largest contractor in terms of annual contract awards. In 1992, MDC received approximately 4.4% of all DoD contract dollars. This is down from 5.9% in 1991. MDC is also one of the top three producers of commercial aircraft. The Boeing Company is the largest producer of commercial aircraft followed by Airbus Industrie and MDC.

In 1992, MDC had a net loss of $781 million on sales of $17.3 billion. This included a one time charge of $942 million that resulted from the adoption of an accounting rule change for retiree health benefits. Not counting the charge, MDC's earnings would have been $161 million. This is down from MDC's 1991 earnings of $423 million on $18.7 billion in sales.

Military aircraft programs were the corporation's largest business segment in 1992 accounting for 42%, or $7.2 billion, of MDC's 1992 revenue. Commercial aircraft were next in size with a 38% share. Missile, space, and electronic systems produced an 18% share of corporate revenue while financial services and other businesses accounted for the remaining 2%.

In 1989, MDC began streamlining operations in response to a trend of reduced defense spending and reduced commercial aircraft orders. Since 1989, MDC employment has dropped by 32% (to 73,000) while aerospace industry employment has dropped 24%. To conserve cash, MDC capital expenditures were held to 70% of depreciation between 1990 and 1992. In 1990, MDC sold its North American Field Service business. In 1991, MDC sold the assets of McDonnell Douglas Systems Integration Company to Electronic Data Systems Corporation. In 1992, MDC sold all of the outstanding stock of TeleCheck Services and in early 1993, MDC completed the sale of its Visual Simulation Systems unit and of McDonnell Douglas Information Systems International.

MDC began a consolidation of aerospace operations in 1992 that resulted in closing three fabrication plants and the creation of MDA-E. MDC's guiding strategy in these actions has been to concentrate on the principal aerospace businesses where MDC is one of the top two producers worldwide or has a clear plan for achieving top two status and to generate enough cash flow for funding major on-going development programs (the C-17 and the MD-11).

With the F/A-18, the C-17, and T-45, MDC has three programs likely to be included in DoD procurement plans well beyond the end of the decade. At the same time, MDC has three programs (the F-15, the AV-8B, and the AH-64) that will be in production for at least several more years while existing foreign orders are completed. This makes MDC the largest producer of military aircraft in the United States. The only major on-going United States military aircraft programs that do not have substantial MDC involvement are the F-22, the V-22 Osprey, and the RAH-66 Comanche.

D.5 Data Gathering

Information on the activities at MDA-E was gathered during a site visit that took place from 10 to 19 November 1993. During the visit, thirty people were interviewed, production operations were observed, and 92 questionnaires were completed by MDA-E personnel. The visit was sponsored MDA-E and supported by the Air Force's F-15 program office.

D.6 Results and Analysis

D.6.1 Policy Framework

D.6.1.1 Corporate Environmental and Pollution Prevention Policies

MDC's current top level environmental policy, dated 3 August 1990, is contained within an integrated occupational safety, health, and environmental quality corporate policy that states:

> It is the policy of McDonnell Douglas Corporation to conduct it business in a socially responsible manner designed to provide safe and healthful operations for its employees, its customers, and the public, to assure compliance with environmental requirements, and to preserve company assets. . .[9]

The policy also specifically calls for each corporate component to, "adopt its own guidelines where laws or regulations may not provide adequate protection," to "evaluate potential health and environmental impacts when selecting and using hazardous materials," to "minimize emissions, effluents, and wastes," and to "integrate occupational safety, health, and environmental practices and requirements into design, test, and manufacturing." The policy states that, "Component management will provide leadership and support," and that, "it is the responsibility of every employee," to assist management in achieving compliance with the policy.

The Minnesota Guide to Pollution Prevention Planning states that a pollution prevention policy statement should provide a clear understanding of, 1) why a pollution prevention program is being implemented, 2) what will be done, and 3) who will do it.[10] The MDC policy generally meets these conditions, but does not specifically call for source reduction or pollution prevention as a preferred alternative for meeting the corporate occupational safety, health, and environmental quality goals.

D.6.1.2 Government Pollution Prevention Requirements

A lack of consistent Government policy was consistently cited during the interviews as a major source of concern and difficulty in implementing pollution prevention at MDA-E. The individual contract requirements are summarized in Table D.2.

The contract for each system has differing pollution prevention requirements and the services have different policies and interpretations for implementing environmental

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[9]McDonnell Douglas Corporation, "Policy -- Occupational Safety, Health & Environmental Quality." (St. Louis, MO: McDonnell Douglas Corporation, 3 August 1993).

[10]Terry Foecke and Al Innes, Minnesota Guide to Pollution Prevention Planning, (St. Paul, MN: Minnesota Office of Waste Management, 1992) 2-1.

mandates such as the ban contained in the FY92 Defense Appropriations Bill on contracts that require the use of ozone depleting chemicals (ODCs).

Program	Contract Requirements
F-15	- None
F/A-18C/D	- None
F/A-18E/F	- Identify unique hazardous materials used in manufacturing and support of the F/A-18E/F. Perform and submit: --Logistics Support Analysis Tasks --Cost Trade Studies --Environmental Analysis Report
AV-8B	- None
T-45	- Reduce & Eliminate --Ozone Depleters --High VOC Topcoats --Methylene Chloride --Cadmium Plating - Evaluate Alternatives --Detergents --UNICOAT TT-P-2756 --Plastic Media Blast --Carbon Dioxide Blast --Benzyl Alcohol --IVD Aluminum - Identify operations and maintenance tasks using hazardous materials. - Identify hazardous material quantities and hazardous waste generation.
A/F-X	- Justify uses of hazardous materials - Identify hazardous material substitutes - Flow-down pollution prevention to subcontractors and vendors

Table D.2. Summary of Pollution Prevention Contract Requirements

To further complicate matters, process and material changes initiated in one program can not be easily adopted in the other programs. Each change must usually be approved individually by each program's service officials before it can be adopted company-wide. In addition, the process for obtaining approval for a material or process change differ from program to program. This results in the need to maintain multiple manufacturing processes and reduces the potential cost and environmental benefits of

implementing changes since the both the old and new processes must usually be maintained concurrently for lengthy periods of time.

D.6.2 Organizational Setting and Scope of Pollution Prevention Activities

D.6.2.1 Organizational Setting

The MDA-E organization can be roughly divided between business units and support units as shown in Figure D.1. Responsibility for providing environmental support to the business units is divided between the Director of Occupational Safety, Health, and Environment and the Director of Environmental Assurance. This structure has proven to have both positive and negative aspects.

The Director of Occupational Safety, Health, and Environment (OSHE) works for the Vice President for General Services. This organization also includes Administrative Services, Transportation, Employee Relations, Facilities, and Security. Historically, the environmental function was a part of Facilities before being combined with Occupational Safety and Health to form an integrated OSHE organization.

The OSHE Director has a manager for each OSHE function. The Environmental and Hazardous Materials Services (EHMS) Manager has a staff of approximately twenty-five people divided into four Groups. The four groups cover 1) operation of treatment facilities; 2) hazardous and solid waste management; 3) hazardous materials control; and 4) pollution prevention (air, water, and other compliance).

The EHMS organization is primarily responsible for regulatory compliance with environmental and hazardous material transportation regulations, operation of treatment facilities, and coordination of MDA-E environmental programs through the Environmental Compliance Committee. EHMS also is responsible for pollution prevention for facility systems. For example, EHMS is responsible for planning to eliminate ODCs from facility air conditioning systems. Environmental Assurance, on the other hand, is responsible for eliminating ODCs in production operations.

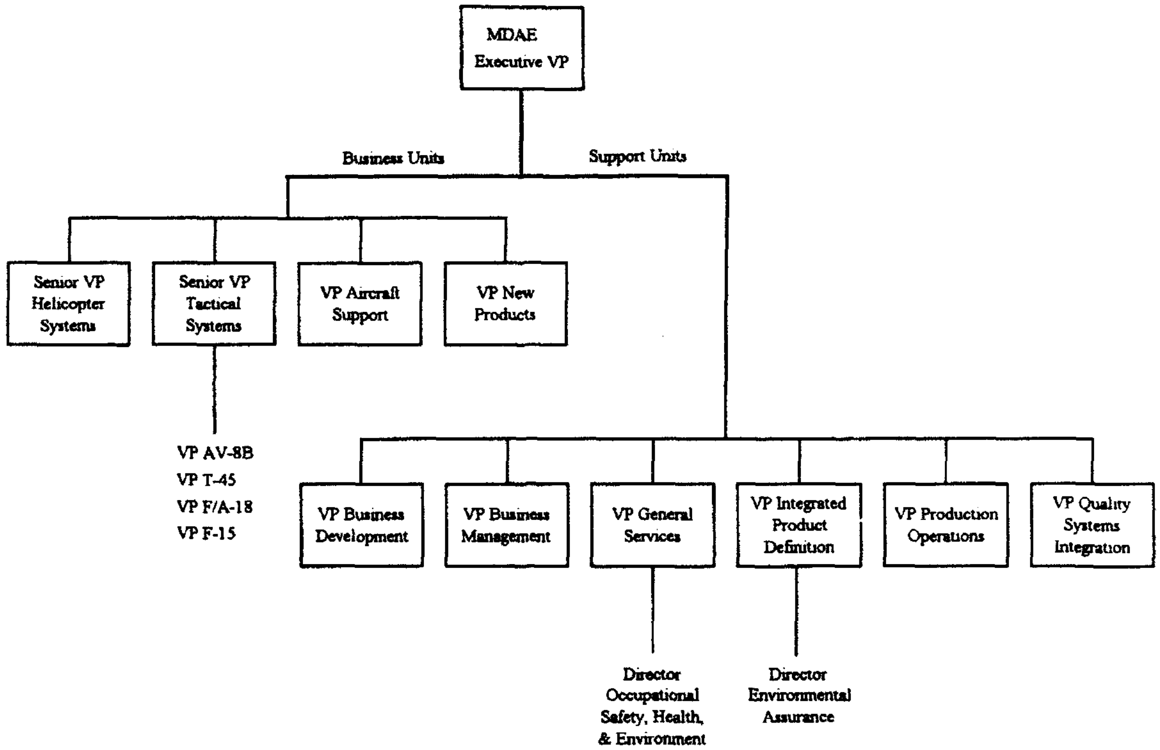

Figure D.1. Partial MDA-E Organizational Chart

The Director of Environmental Assurance (EA) reports to the Vice President for Integrated Product Development (IPD). This organization includes most of the "core" functional organizations that set technical policy and supply specialists to support individual programs. IPD is made up of eight major functions and includes Engineering, Manufacturing Processes & Definition, Quality Engineering and Planning, Flight & Laboratory Operations, Product Support, IPD Processes and Tools, and Supplier Management and Procurement.

EA was formed by "pulling" people from throughout the IPD organization with strong support from its Vice President. While the majority of people have engineering backgrounds in materials and processes, EA also has a good mix of professionals with other backgrounds such as logistics, planning, and procurement.

This integration of people with different functional backgrounds into a single environmental organization is unique among the companies visited. Others are trying to achieve integration on individual programs using integrated product teams or are trying to achieve plant-wide integration with a coordinating committee structure, but no else has put the people together into one office.

With this mix of backgrounds, EA is significantly different from EHMS where most the staff have backgrounds in environmental engineering and facilities management. A further difference between EA and EHMS involves the career paths of the staffs. While most of the EA staff have worked in one or more programs during their careers, very few in EHMS have program experience. These differences are reflected in each organization's focus.

Environmental and Hazardous Materials Services (EHMS)

Regulatory Compliance & Risk Management

- Hazardous Materials Control
- Pollution Prevention
- Waste Management
- Environmental Operations
- Environmental Compliance Committee

Environmental Assurance (EA)

Process Improvement & Technology Development

- Hazardous Materials Minimization
- Engineering Technology
- Product Design and Support
- Planning and Studies
- Process Action Team (Forward Pricing)

Table D.3. Environmental Responsibilities

As shown in Table D.3, EHMS is focused on permits, regulatory reporting, compliance and hazardous materials management, and operation of treatment facilities.

EA, on the other hand, is primarily concerned with planning for new materials and production processes to support MDA-E product development and production. In creating EA, IPD's Vice President recognized the need to integrate environmental thinking and planning into the core technical functions at MDA-E.

EA is organized into four groups: 1) Requirements Analysis and Program Support, 2) Planning and Studies, 3) Engineering Technology, and 4) Project Implementation. Each group has an important role in planning and implementing environmental initiatives.

The Requirements Analysis and Program Support staff provide a comprehensive listing of compliance requirements that may impact MDA-E operations. This is one the key features of the EA strategic planning process. In addition, the group supports the program offices and participates in a wide array of programs with EHMS and other functions such as compliance reviews, waste minimization, and hazardous materials tracking. The Planning and Studies group is responsible for implementing the strategic planning process and for conducting all needed cost analyses, trade studies, and business case studies. Engineering Technology is responsible for investigating new materials and processes. They accomplish this by sponsoring internal MDC research, coordinating on-going research efforts sponsored by other MDC organizations, and investigating outside technologies. Project Implementation is responsible for managing and tracking projects.

D.6.2.2 <u>Pollution Prevention Program Scope and Key Features</u>

Pollution Prevention efforts at MDA-E include strategic planning, developing new materials and processes, improving management systems and processes, and implementing source reduction initiatives. The greatest strength of MDA-E's pollution prevention program is strategic planning. In 1993, EA and EHMS employed separate processes. This produced some minor turf battles, but the experience led to new insights in both organizations. Both processes are described below.

EA states that the purpose of its strategic plan is to define what must be done, why it must be done, when it must be done, and how much it will cost. The completed plan describes the activities needed to implement environmentally compliant processes and to replace hazardous materials with acceptable alternatives over a six year planning horizon.

The key elements of the planning process are shown in Figure D 2.[11] The process begins with a analysis of environmental compliance regulations that EA calls Directives Analysis. This analysis looks at compliance requirements and potential requirements for all MDA-E operating locations and details the required compliance dates, control limitations or other requirements, and assigns a maturity classification.

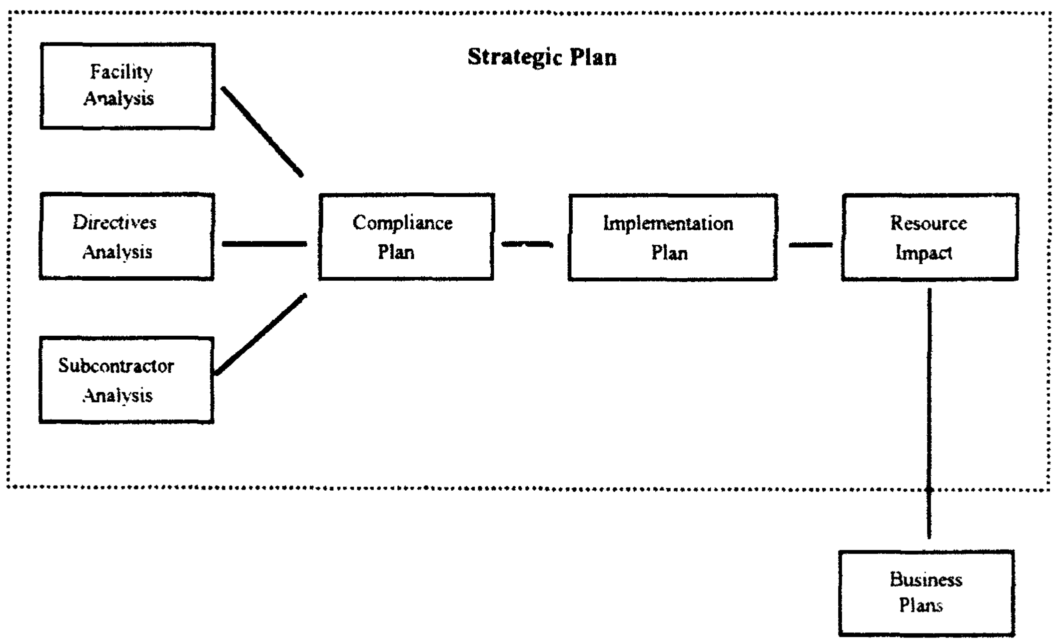

Figure D.2. MDA-E Strategic Plan Elements

The maturity classification indicates the likelihood that each requirement will become a firm compliance requirement. The system assigns each requirement to one of

[11] Ron Aarns, "Environmental Assurance - Strategic Planning Process," discussion charts provided in interview by author, McDonnell Douglas Corporation, St Louis, Missouri, 12 November 1993

the five classifications shown in Table D.4.[12] During development of the 1993 plan, 141 directives were identified and classified, with twenty assigned to class 1 and seventeen assigned to class 2. The remaining 104 directives were assigned to classes three, four, and five.

Class 1	Documented directives with firm, specified control limitations and known compliance dates
Class 2	Unreleased directives, or expected revisions to existing directives, with scheduled release and compliance dates, near certain limitations, but not yet binding.
Class 3	Unreleased directives, or expected revisions to existing directives, with a scheduled release date, but evolving control limitations.
Class 4	Directives, or revisions to existing directives, under development with no scheduled release date.
Class 5	Speculation on potential future directives

Table D.4. Directive Maturity Classification System

Armed with an itemized requirements listing from the directives analysis, teams are assigned to evaluate each facility to identify processes that will be impacted by the upcoming directives. The Facility Analysis looks at required changes over a six year planning period. The final input to the Compliance Plan comes from analyzing the environmental requirements and efforts of MDA-E's subcontractors and suppliers. The Subcontractor Analysis assesses the need to modify process and material specifications or contract terms to support MDA-E's strategic plan.

During the compliance planning portion of the process, the collective requirements on each process are considered and "initiatives" are established that outline general courses of action that will meet the requirements. Once a comprehensive list of initiatives is completed, business cases are logically organized for addressing the initiatives. For each business case, specific solutions are analyzed to determine each solution's ability to meet

[12]Ibid.

the set of applicable requirements. In 1993, this process produced thirty-six initiatives that were assessed in twenty-two business cases.

Each business case identifies the operation involved, the directives impacting the operation, describes the operating levels and purpose of the operation, and evaluates alternate solutions based on probable production and quality impacts, and on risks, and costs.

A qualitative risk analysis matrix , as shown in Figure D.3,[13] is developed for each business case. One axis lists the potential solutions and the other contains a listing of nine risk categories. Potential solutions are rated as low, medium, or high risk in each risk category.

Potential Solution

Risk Category	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5
Non-Compliance within Timeframe					
Non-Compliant Technology (Solution)					
Failure to Accurately Forecast Requirements					
Adverse Impact on Production Performance					
Adverse Impact on Product Quality					
Adverse Impact on MDAE Finances					
Excessive Design/Documentation Changes					
Adverse Impact on Future Production Contracts					
Non-Compliance with Future Regulations					

Figure D.3. Risk Analysis Summary Matrix

A risk matrix along with a project description, schedule, and resource estimate is then packaged together into a project outline for each potential solution. The project

[13]Ibid.

outlines are then reviewed by a Technical Review Committee. Based on the information contained in the project outlines, the TRC recommends a final solution. The recommendations are then reviewed and approved by an Executive Review Committee.

Once approved, the collection of business case studies and project outlines of the approved projects make up the Compliance Plan. The Implementation Plan contains project work plans that document the work to be accomplished by each project, a project schedule, staffing requirements, and a detailed budget. Resource impacts are projected by year. This information is then provided for incorporation into unit business plans.

The EA strategic planning process has been used for one complete planning cycle. The final product was a strategic plan that was distributed to managers throughout MDA-E that addresses compliance issues that may impact MDA-E operations. While EA was creating and implementing this process, OSHE continued to produce its own strategic plan.

The annual OSHE Strategic Plan uses a very different planning methodology. The OSHE planning process begins with a set of corporate OSHE strategic objectives that are taken from the MDC corporate OSHE Strategic Plan. The corporate objectives are set after a set of recommendations is developed by a planning conference attended by OSHE managers from major MDC units.

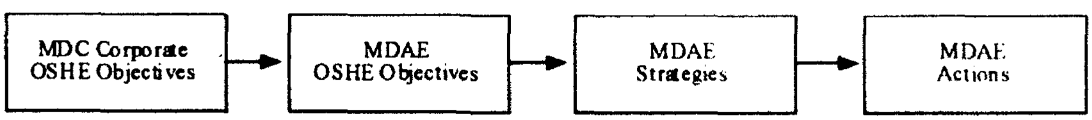

Figure D.4. OSHE Strategic Planning Process

The OSHE planning process in shown in Figure D.4. The process is initiated each year when an updated set of corporate OSHE objectives is set. In addition, the corporate staff issues a set of annual technology guidance. This allows the business units to tie

corporate technology thrusts to business unit strategic plans. Each business then updates its strategic plan. Performance is measured for each objective on a quarterly basis. The process has been on-going since the first plan was done in 1989. In 1992, MDA had twenty-four strategic OSHE objectives.

The 1992 objectives cover a full range of both management and programmatic occupational safety, health, and environmental issues. In the management area, objectives address training, project reviews, communications, customers, and other areas. The environmental programmatic objectives cover air emissions, waste minimization, hazardous materials, groundwater protection, and the EPA's 33/50 Program. The programmatic objectives include metrics for measuring progress. For example, the objectives include a 90 percent reduction in Toxic Release Inventory air emissions by the end of 2000, a 90 percent reduction in hazardous waste generation by the end of 2000, and meeting the EPA's 50 percent voluntary reduction in the releases of seventeen target chemicals by the end of 1995. Baseline years for measuring progress toward these objectives vary. For example, for EPA's 33/50 program, 1988 was selected by EPA as the baseline year and MDA-E uses a 1988 baseline. For other objective, the baseline was set based on when the objective was set or based on when the first reliable data was recorded. Management objectives cover topics like developing and improving hazardous materials control, handling, storage, and use procedures; improving communications with top management on environmental issues; and enhancing line management accountability for environmental issues.

The EHMS staff has the responsibility for developing the strategies and actions for meeting the environmental objectives. The staff is assisted by the Environmental Compliance Committee. The committee is tasked with planning, coordinating, and oversight functions and has representatives from all key MDA-E functions. Working groups are organized as needed to address specific issues. For example, in support of the

hazardous waste reduction goal, a working group is assigned for each major MDA-E hazardous waste stream.

The completed strategic plan covers each objective, listing the associated strategies and actions. Labor and capital estimates are included for each objective. Most of the environmental objectives are capital intensive. Improving the management of hazardous materials is an exception. This objective is labor intensive.

The fact that improving management of hazardous materials is labor intensive, is a clear indication of the complexity of the issues involved. Hazardous materials management impacts many functions and involves changing many procedures and integrating information from many data systems. To accomplish the tasks identified in the strategic plan, a multi-disciplinary team has been established to address the procurement, storage, transportation, accounting, data automation, and other related functional concerns.

MDA-E uses over 20,000 different materials in its operations and averages over 100 hazardous material purchase requisitions per day for production materials. Each requisition is now being reviewed by a buyer trained to recognize potential problems and to implement MDA-E control procedures. Purchases of non-production materials are not currently reviewed on an individual basis.

Procedures for reviewing all new hazardous materials, equipment, and processes before they are purchased or brought on site for the first time were established in March 1993. The new procedures allow each request to be reviewed by occupational safety, health, and environmental personnel prior to purchasing action. Upon approval, requesters are provided guidance on meeting OSHE requirements that includes information on appropriate engineering controls, pollution controls, disposal, training requirements, worker safety, and related issues. In the first six months since the new procedures were introduced, approximately 200 requests for new chemicals have been

reviewed. The review process typically adds five to ten days to the time required to make a first time purchase, but can be completed more quickly if needed.

Another key element in the strategy for improving hazardous materials management is implementing a Hazardous Materials Tracking System (HMTS). The HMTS will be an on-line data system that ties together data from many existing sources. The HMTS will also support hazardous materials tracking using a bar-coding system. This part of the system is near to pilot testing. Other hazardous material management improvements involve management procedures such as control for hazardous materials hand carried onto MDC property, development of a hazardous material life cycle checklist, and improved shipping and inspection procedures.

In summary, EA and EHMS have both played an important role in implementing pollution prevention at MDA-E but the organizations tend to have different approaches to environmental management. EA's approach is requirements driven. They tend to start an analysis with a list of specific requirements, usually compliance requirements. This approach is at the core of the system engineering approach using in the programs. EHMS's approach, on the other hand, typically starts with an environmental problem such as hazardous waste generation is too high, or solid waste disposal costs too much. Both approaches are necessary and appropriate. One of MDA-E's challenges it to combine the approaches into an integrated planning and management concept.

D.6.2.3 Corporate Record on Environmental Issues

Unlike the aerospace companies in southern California and other locations, MDA-E has enjoyed relatively cordial relationships with both the Missouri and City of St. Louis environmental regulators. In the past, State and local air regulations have had little impact on MDA-E operations. There are no current outstanding regulatory notices of violation or other compliance related legal proceedings impacting MDA-E operations. MDA-E is

involved in the cleanup of several Superfund sites. By comparison, MDA-W has not been so fortunate.

In September 1992, the U.S. EPA cited MDA-W's Huntington Beach facility with discharging waste into the sanitary sewer in violation of discharge limits. The complaint was settled in a September 1993 consent decree requiring MDC to pay a $505,000 civil penalty. In June 1993, the Long Beach plant was cited for discharging caustic material to the storm sewer. The matter was also settled in September 1993 and required MDC to make a $125,000 payment into a trust account to be used by the City of Long Beach for environmental projects.[14]

Current EPA criteria require facilities that use more than 10,000 pounds of a TRI chemical per year to submit an EPA Form R on each chemical that exceeds the threshold. The first TRI reporting was done in the summer of 1988 and covered releases in calendar year 1987. A summary of MDA-E's TRI data from 1988 through 1992 is shown in Table D.5.[15] The data was provided by MDA-E. The TRI data for years 1988 through 1990 was verified against EPA's TRI data base. The newer TRI data was not yet loaded in EPA's data base. MDA-E submits much of the same data to the State of Missouri to fulfill the state's annual emission inventory requirements.

MDA-E is a voluntary participant in the EPA's 33/50 Program, which calls for reduction of the releases in seventeen chemicals by 33% by 1993, and 50% by 1995 based on a 1988 baseline. Based on their 1988 baseline of 642,783 pounds, MDA-E has only achieved a four percent reduction through 1992. MDA-E's 1988 baseline for total TRI is 801,883 pounds. For 1992, the most recent year available, MDA-E reported total releases

[14]US Securities and Exchange Commission, "McDonnell Douglas Corporation 10-Q Report," (Washington D.C.: US Securities and Exchange Commission, 30 September 1993), 33, Commission File Number 1-3685.

[15]McDonnell Douglas Aerospace - East, "SARA 313 Summary," McDonnell Douglas Corporation, St. Louis, Missouri, 8 July 1993.

of 709,027 pounds. This represents an overall reduction of twelve percent from the 1988 baseline.

Bold Chemicals are part of the EPA 33/50 Program
(All Figures are Total Chemical Releases in Pounds)

Chemical	**1988**	**1989**	**1990**	**1991**	**1992**
Ammonia	13,400	16,100	19,500	10,300	7,100
Benzene	1,213	1,500	820	950	60
Chromium Compounds	250	250	250	10	606
Freon 11	N/A	N/A	20,400	16,300	10,040
Freon 12	N/A	N/A	12,000	13,540	18,550
Freon 113	122,900	117,160	72,800	50,600	17,450
Hydrochloric Acid	500	500	500	30	28,100
Hydrofluoric Acid	1,000	1,450	1,350	20	3,650
Lead Compounds	70	250	250	60	60
Methanol	19,800	5,950	3,250	2,400	400
Methylchloroform	236,750	191,450	175,550	194,950	231,700
Methyl Ethyl Ketone	132,000	196,000	283,000	125,700	132,650
Methyl Isobutyl Ketone	19,000	17,000	18,900	22,600	8,251
Methlene Chloride	17,500	25,000	50,000	26,200	39,100
Nitric Acid	500	1,000	1,000	1,030	1,080
Perchloroethylene	52,750	46,750	88,300	60,900	9,750
Phenol	0	9,100	0	0	0
Phosphoric Acid	500	500	500	330	180
Sulfuric Acid	500	0	500	420	6,350
Toluene	20,000	28,250	37,750	36,200	15,250
Trichloroethylene	163,250	194,250	301,000	276,100	178,700
Xylene	0	0	8,150	0	0
33/50 Program Releases	642,783	700,700	963,970	743,670	616,127
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Totals TRI Releases	801,883	852,460	1,095,770	838,640	709,027

Table D.5. MDA-E Toxic Release Inventory (TRI) Reporting
From 1988 through 1992

MDA-E's basic TRI data is derived from material purchase records. Releases reported in the TRI are then either calculated or estimated from the known amount of material that was brought on site. None of the MDA-E's reported TRI data is obtained from actual release measurements.

A check of past reports shows that MDA-E has not submitted any information in the optional pollution prevention section of its TRI reports. This section of the EPA Form R allows a facility to report source reduction activities that were implemented during the reporting year. A lack of time was cited as the reason for not including information on the company's source reduction activities.

Production ratios reported in MDA-E's TRI reports are closely coupled to the use of each chemical. For example, the production ratio for ammonia releases is based on the square footage of blueprints produced, the only use of ammonia. Since solvents are primarily used in production, the solvent group of TRI chemicals all use a production ratio based on the square footage of aircraft surface area produced. The advantage of having a close relationship between chemical releases and the related production processes is that the TRI data can be adjusted for production changes to give a better indication on the progress of reduction efforts. Although the EHMS staff has developed a well thought out set of production ratios, there was no indication that MDA-E management uses the production ratios in its internal analysis and reporting systems.

D.6.2.4 Pollution Prevention Implementation and Results

MDA-E's approach to implementing pollution prevention in its programs starts with meeting all program specific requirements as described previously. Where program specific requirements do not exist, the program manager relies on the program's manufacturing staff and its material and process engineers to ensure that the production materials, processes, and products are compliant with corporate and regulatory environmental requirements at MDA-E facilities.

Program specific hazardous material management program (HMMP) plans are being developed for programs where MDA-E is involved in an on-going product design and development effort. The program specific HMMP plans are directly linked to the EA Strategic Plan. In order to allow the overall structure of each program's HMMP to be

standardized, MDA-E was a leader in the Aerospace Industries Association's (AIA) development of National Aerospace Standard (NAS) 411, "Hazardous Materials Management Program."[16]

NAS411's purpose is to set a common standard for defining how a company will influence the product design process to eliminate, reduce, or minimize hazardous materials in acquisition programs while also minimizing system cost and risk to the system's performance. The intent is for the contractor to be able to apply a similar approach company-wide, and not have to set up a different approach for each acquisition program.

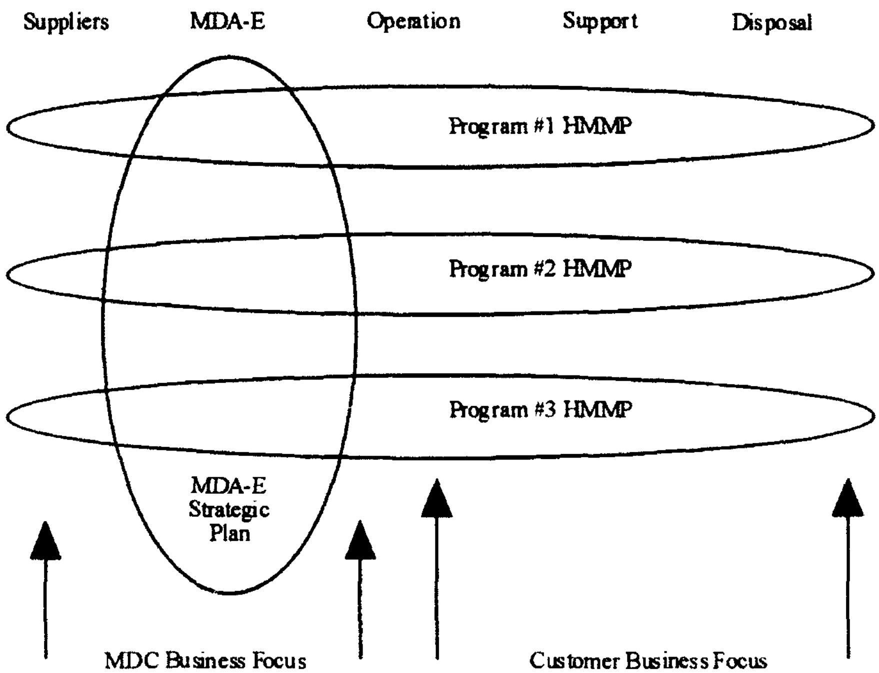

Figure D.5. Relationship Between the MDA-E Strategic Plan and Program Hazardous Material Management Plans (HMMP)

In moving toward a system of program specific plans that are tightly linked to the work of the core environmental activities, MDA-E is prototyping the NAS411 approach in

[16]Aerospace Industries Association, National Aerospace Standard NAS411, "Hazardous Materials Management Program," (Washington D.C.: Aerospace Industries Association, 1993) 1.

the F/A-18E/F development program. The relationship between each program HMMP plan and the MDA-E EA Strategic Plan is shown in Figure D.5.[17]

Each program HMMP will address the life-cycle of the system, covers program specific issues, identifies cost effect solutions, and tasks implementation of the solutions for the program. The MDA-E strategic plan on the other hand, has a MDC business focus, is prepared by the MDA-E core staff, addresses common materials and process issues, identifies MDA-E compliance requirements and projects for addressing the requirements in on-going production operations, and addresses research and development requirements for new technologies.

For 1994, the EA strategic plan includes projects for eliminating the use of ozone depleting chemicals in production processes, switching to low volatile organic compound (VOC) content coatings, reducing emissions from vapor degreasing, and implementing waterborne chemical processing maskants. Projects identified for future years include implementing new technologies for powder coatings, electropriming, adhesive bonding primers, non-chromated conversion coatings, and paint stripping technologies. Additional applications for aqueous degreasing are also planned.

Figure D.6[18] shows how the information in the EA strategic plan will be used in developing program specific HMMP's. A good example of the interaction between program and core responsibilities is MDA-E's ODC elimination efforts.

Each MDA-E program manager has had to respond to one or more program specific Government requests for information on impacts and costs associated with implementation of service, DoD, and Congressional ODC policies. Since the programs share the same production facilities, close coordination between core and program staff is

[17]Richard E. Pinkert, "Overview of McDonnell Douglas Aerospace - East Environmental Assurance Organization," discussion charts provided in interview by author. McDonnell Douglas Corporation, St. Louis, Missouri, 10 November 1993.

[18]Paul Stifel, "Project Implementation," discussion charts provided in interview by author, McDonnell Douglas Corporation, St. Louis, Missouri, 10 November 1993.

essential to implementing ODC policies in a cost effective manner. If this coordination does not occur, much duplication of effort will occur and much time will be wasted covering the same issues in each program.

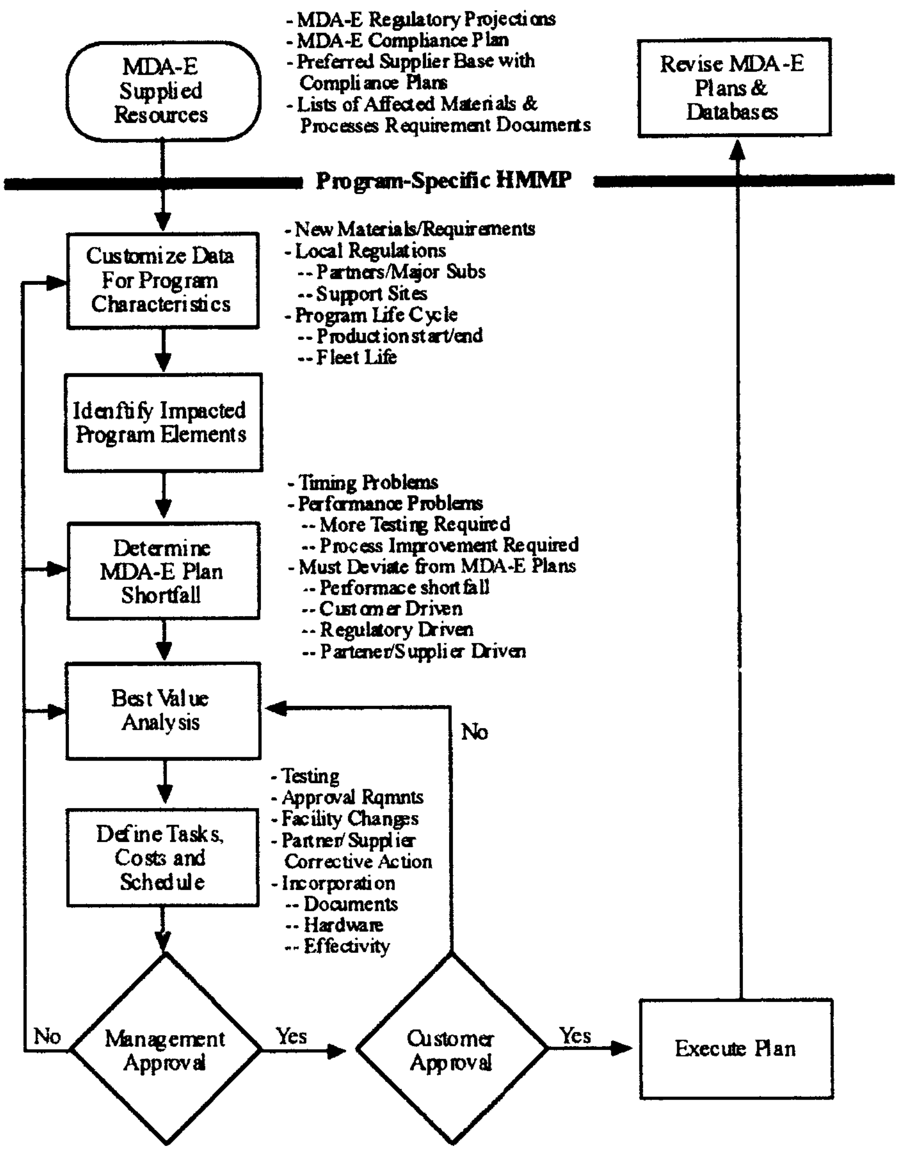

Figure D.6. Logic Diagram for Developing Program Specific Hazardous Materials Management Plans

To prevent this from happening, EA developed a process flow chart identifying the tasks required for implementing ODC policy caused changes and assigned each task to the

program or core staff. For example, reviewing technical publications to identify where ODC use is required in a system is a program task while identifying replacement chemicals is an EA task. Once the tasks were assigned, solutions were identified and funding issues were assessed.

Since many manufacturing processes are shared among programs, EA recommend common solutions to like problems. This is in the interests of both MDA-E and the Government. These potential changes are identified in the EA strategic plan. Funding turned out to be a problem, however. None of the individual Government program managers wanted to pay for changes that benefited all the programs. To move the process forward, MDA-E decided to fund all non-unique (to one system) manufacturing process changes from corporate resources. The costs associated with these changes will then be borne by each program as part of MDA-E's general overhead rate that is applied to all programs. Program unique processes and problems, must be funded by the program. Changes to the technical manuals for a system, for example, must be paid for through a change to the program contract. Redesign and requalification of system hardware are also program specific funding issues.

D.6.2.4.1 F/A-18E/F Program Implementation

Pollution prevention is being carried out within the logistics function of the program. This placement fits well within the structure of program, but the lack of environmental requirements in the system requirements document greatly reduces the potential influence of the environmental staff. This situation arises from the fact that the aircraft portion of the system specification contains no pollution prevention or other environmental requirements.

The environmental requirements for the E/F are contained in the logistics support analysis (LSA) portion of the contract. The contractual environmental tasks are illustrated

in Figure D.7.[19] The environmental portion of the process occurs as a part of two LSA tasks: Task 204, Technology Opportunities; and Task 401, Task Analysis.

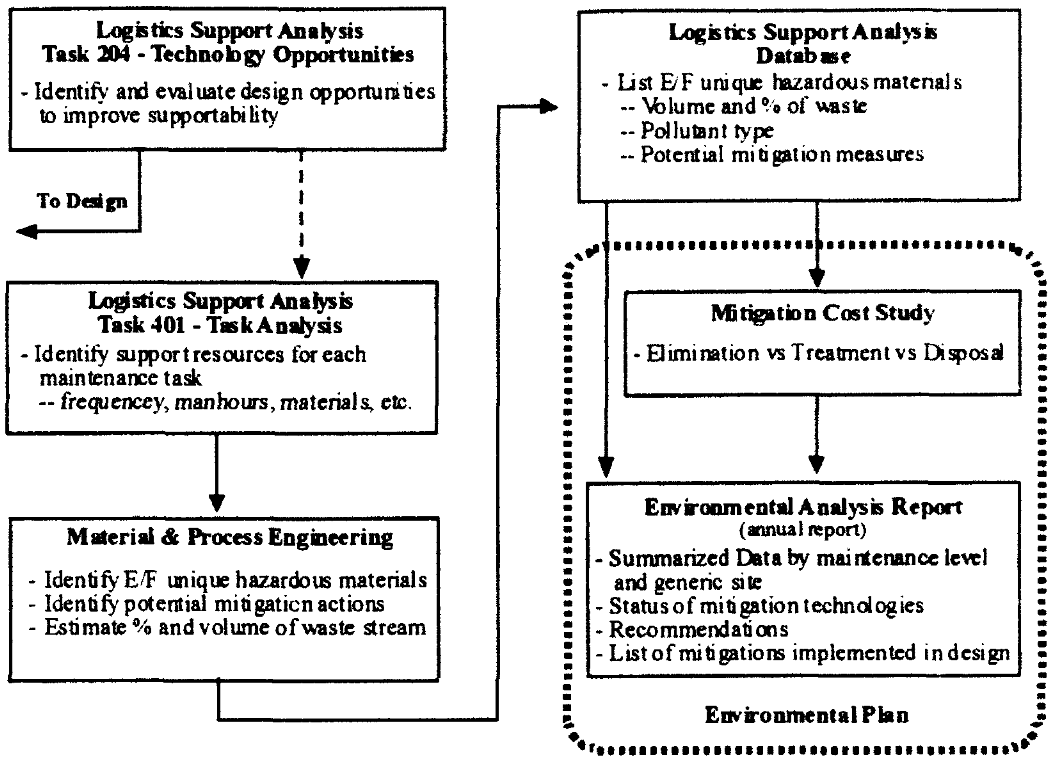

Figure D.7. F/A-18E/F Environmental Analysis

The portion of the LSA process shown represents a small part of the overall LSA effort. For the F/A-18E/F, the contractual LSA requirements are a tailored subset of the complete LSA process described in MIL-STD-1388.

Under Task 204, MDA-E is required to assess opportunities to improve system supportability by identifying technological advances and other design improvements which have the potential for reducing logistic support requirements, costs, or environmental impacts; improving safety; or enhancing system readiness. The intent of this task is to provide logistics inputs early in the design process. For the F/A-18E/F, environmental

[19]McDonnell Aircraft Company, "F/A-18E/F Integrated Logistic Support Environmental Analysis Plan," (St. Louis, MO: McDonnell Aircraft Company, 23 September 1991), 2-6.

inputs from this task are based on MDA-E's compliance requirements as identified in their EA strategic plan. There were no customer inputs identified by either the Navy or by MDA-E.

Task 401, which contains most the contract's environmental requirements, requires MDA-E to assess opportunities to improve supportability and to identify and evaluate E/F aircraft unique hazardous materials that will be used in manufacturing or support. This includes carrying out task analyses of all maintenance and repair activities. Task analysis has limited impact on the design process; however, since the bulk of the analysis occurs following critical design review. This makes it impossible for MDA-E to use information from Task 401 to "design out" hazardous materials during the concurrent engineering process. Since source reduction items are not presented in the design process in a timely way, potential changes require reconsideration and potential redesign resulting in higher implementation costs.

In spite of the timing problems associated with Task 401, the program staff has the benefit of the comprehensive MDA-E strategic plan that addresses the environmental issues associated with manufacturing materials and technologies. This information is being considered by the integrated product development teams selecting materials and production processes for the F/A-18E/F. This will result in numerous changes to the processes currently used on the C/D to meet MDA-E environmental requirements. Incorporating MDA-E's environmental requirements means that the E/F will be a "greener" aircraft than the C/D. How much additional improvement could have been incorporated into the E/F by considering the Navy's environmental requirements in a timely fashion during Engineering and Manufacturing Development will never be known. MDA-E has requested funding to determine the Navy's requirements, but the funding has not yet been provided. Other options open to the Navy include conducting the analysis in-house or contracting with an independent company.

To order to produce and operate the F/A-18E/F, the Navy must issue a series of additional contracts for work not included in MDA-E's current contract. Under the Navy's proposed specification for Low Rate Initial Production (LRIP) Lot #1 of the F/A-18E/F, MDA-E has proposed conducting research on applicable environmental laws and regulations at E/F operating and repair sites, funding for core MDA-E logistics and EA personnel to support "Green Hornet" team meetings, identification of approved hazardous materials handling methods, and recording unique E/F hazardous materials data in the LSA database. Pollution prevention planning and implementation for supporting the existing F/A-18C/D fleet may be funded in a modification to an existing support contract. The effort as currently envisioned will include funding for research on applicable environmental laws and regulations at operating and repair sites for the C/D aircraft. The research would be similar to the requirements analysis conducted for the EA strategic plan. In addition, current planning also calls for funding manhours for "Green Hornet" team meetings and development of a hazardous materials database for C/D support materials.

D.6.2.4.2 Environmental Metrics

MDA-E has established a number of metrics for assessing its OSHE strategic objectives. For example, hazardous waste generation is tracked monthly and generation figures are normalized using direct labor hours to help account for variations in production. Other MDA-E metrics include: total TRI releases, TRI air toxic releases, Industrial Toxics Program chemical releases, and ODC use. The OSHE staff also has metrics for tracking many of the subobjectives under the high level metrics listed above.

The number of metrics being tracked is adequate for describing MDA-E progress against its objectives. The greatest weakness with MDA-E's environmental metrics is that they are not widely distributed or used by management.

D.6.2.4.3 Management of Pollution Prevention Objectives

One of OSHE's strategic objectives involves increasing line management's awareness and accountability for occupational safety, health, and environmental issues. The need for better communication with line management was clear. Outside the OSHE organization, very few mangers or professional staff members were aware of OSHE's objectives or their metrics. One exception to this is ODC elimination. Management and staff in both the programs and the core organizations were familiar the requirements, the issues, and MDA-E's progress.

Part of this high level of awareness can be explained by the programs' need to respond to customer questions in this area; however, much of the success in communicating on ODCs is due to the integrated program development style approach that has been applied to this issue.

D.6.2.4.4 Pollution Prevention and the National Environmental Policy Act (NEPA)

There was no evidence that programmatic NEPA analyses have had any impact on pollution prevention in the programs. Most of the programs have contractual provisions to provide aircraft noise data and other technical information to the government's NEPA analysis. Once the data is provided, MDA-E appears to get little or no government feedback on the environmental impacts associated with fielding the systems.

Evidence that MDA-E receives little feedback can be found in recent acquisition proposals. In every program, the staff has worked with the government in reviewing or writing "draft" and final statements of work (SOW) for future contracts or contract modifications. As part of the SOW development process, the MDA-E staff has shown that it is very knowledgeable on the environmental problems at the government's depots. This is to be expected since the military depots represent large industrial complexes and have many of the same concerns as a manufacturing facility. A similar level of knowledge of the customer's environmental problems at the operating installations was not observed.

Since the operating installation impacts are extensively studied and documented in the NEPA process, this indicates that the government is not effectively using its NEPA analysis to impact system requirements or system design.

D.6.3 Implementation Contextual Factors

The seven factors discussed in this section are commonly cited in the implementation literature as being important for understanding an implementation process. Observations concerning the impact of each factor on the pollution prevention implementation efforts at MDA-E are presented below. The observations are relative to MDA-E's implementation of its internal pollution prevention policies as well as government requirements.

D.6.3.1 Organizational Structure and Relationships

Organizational structure is an important factor in the way pollution prevention is being implemented at MDA-E. The overlapping roles and responsibilities of OSHE and EA have created some organizational rivalry, but so far the competition has been mostly healthy and has served to sharpen and focus both organizations. Creation of EA brought seasoned managers from non-environmental backgrounds and a wide array of technical talent into the environmental area. This has strengthened the overall program at MDA-E by bringing together the technical and management resources needed to better understand and attack the problems associated with integrating pollution prevention into the business units.

Another key organizational process at MDA-E is the on-going effort to improve its integrated product development (IPD) process. MDA-E's IPD concept uses multi-disciplinary teams in a system that blends systems engineering, simultaneous development, and lean manufacturing. The MDA-E IPD process draws heavily from draft MIL-STD 499B, Systems Engineering, and specifically addresses including product supportability issues, including customer environmental concerns. Consideration of the product life-

cycle is a key element of the IPD methodology at MDA-E. It is also a key element in implementing pollution prevention along with the use of multi-disciplined teams.

D.6.3.2 Goal Structure

The goal structures within the system acquisition process and at MDA-E serve to limit the scope of pollution prevention activities. Some of the conflict results from business realities, but much of the conflict has other roots.

MDA-E must respond to two types of environmental requirements: 1) MDA-E manufacturing requirements, and 2) customer (product support) requirements. Both types are constantly changing. EPA regulations substantially change on a seven to ten year cycle as Congress re-evaluates and changes programs. This introduces a highly dynamic variable into both corporate business planning and the system acquisition process. The development portion of acquisition cycle alone, phase 0 through phase 2, is often longer than the EPA cycle.

The result of having multiple types of changing requirements is goal conflict. Acquisition programs are structured to develop and build systems that meet specific mission and performance requirements using a "fixed" cost and schedule. A basic tenant of managing systems development in DoD is to avoid changing requirements wherever possible. Since the dynamic nature of environmental requirements do not allow them to be precisely defined before starting system development, conflict results.

The only other system design variable that is this dynamic is the mission threat assessment. Over the life of a development program, the threat is updated on a regular basis and the program "is allowed" to change to meet the changing threat. Meeting environmental requirements also requires continuous planning and evaluation, but the acquisition process does not recognize this source of cost and schedule uncertainty. Thus, both government and company managers are not sure of what is expected of them.

Another goal conflict arises from MDA-E's environmental planning being internally focused. EA's strategic planning focuses on minimizing the financial impact of environmental directives. Customer requirements are not routinely considered unless MDA-E is contractually bound to do so. This is at odds with the IPD philosophy. This is beginning to change; however, as MDA-E recognizes that a strong environmental effort capable of addressing customer environmental issues can be a competitive advantage.

D.6.3.3 Knowledge Base

MDA-E has an excellent knowledge base for implementing pollution prevention and actively seeks to improve it. For example, protective coatings are a major challenge to MDA-E's compliance with the 1990 Clean Air Act amendments. To better understand the problems and potential solutions, the technical manager of a paint company was brought on as a new MDA-E employee. This occurred during a time of large job losses at MDA-E.

In addition to getting outside technical help where needed, MDA-E has been actively training its current employees. For example, every employee in the core IPD organization has completed an IPD training course. At the beginning of the MDA-E effort to win the A/F-X development contract, every person on the A/F-X team received environmental awareness training.

The knowledge base is also enhanced by a strong internal research program on new materials and clean manufacturing techniques. Taken together, all these factors indicate that the knowledge base is not a major implementation issue.

D.6.3.4 Resources

Pollution prevention represents one of the many organizational goals MDA-E is pursuing, limiting the resources available for implementation, but MDA-E resources have not been a critical constraint. The number of core employees working on environmental issues has increased dramatically in the last two years while MDC's overall employment

was dropping over about the same time frame. There has also been an extensive effort to reduce overhead costs within MDA-E, but environmental programs have expanded. In addition, internal research and development funding for environmentally beneficial projects has increased. While MDA-E controls allocation of funding for its core "overhead" resources, it must negotiate the resources available in the programs. Getting the government to recognize and pay environmental costs is not always easy.

The F/A-18 was designed twenty years ago and has been in production ever since, but more changes will occur in the production processes in the next two years than since production began. MDA-E is negotiating the cost for building thirty-six aircraft (FY94 budget) to be delivered in 1995-1996. The latest audited cost data that can be used in the negotiations ends in 1990. Since MDA-E has undertaken most of its environmental initiatives since 1990, this historical cost data is not a good basis for determining MDA-E's environmental costs.

In addition, accounting for and negotiating environmental costs is complex. Costs incurred when the Government acts in its sovereign capacity are not recoverable. MDA-E is obligated to meet the terms of its government contracts when EPA issues new regulations--even if the regulations substantially increase the cost of performance. On the other hand, costs incurred by MDA-E for meeting environmental requirements imposed through contract changes are fully recoverable. To help MDA-E both plan and negotiate, EA is leading a forward pricing study to determine what the future level of environmental expenditures will be and how to incorporate them into business decisions and contracts.

The resources available within the programs have not substantially changed over the past several years. Unlike the core employees that are charged to overhead, program employees are directly paid for under the program contracts. Getting resources for additional program employees to work environmental issues has been more difficult, but program resources are improving.

The most recent T-45 logistic support contract includes a number of environmental requirements. MDA-E's estimated cost for meeting the requirements included a level of effort consisting of five full time employees for a 27 month performance period. The contract is a firm, fixed-price contract.

Another problem area has been resources to make changes to government-owned technical documentation including design and production documents and technical manuals. ODC elimination is a good example of this. No military program at MDA-E has yet been funded to begin making the needed changes. Thus, even though many of the changes that must be made have no outstanding technical issues, no funding for the paper work is available. In preparing proposals for the Government on ODC elimination, MDA-E has discovered that the cost to change the program technical documentation far exceeds the costs of finding and implementing the changes. A key finding from this effort is that technical documentation systems must be redesigned to reduce the costs associated with making changes.

D.6.3.5 Dispositions

The overall disposition of MDA-E employees on environmental issues was observed during each interview and was evaluated using a questionnaire during the site visit. Results of the questionnaire are presented in detail in Appendix F. A summary of the survey results is presented below.

The questionnaire consisted of a total of 27 questions and contained questions on six general topics: environmental behavior, environmentalism, environmental concerns, pollution prevention, and environmental performance. Twenty of the 27 questions were taken from national surveys on the environment.

At MDA-E, the employees answered twelve of twenty questions differently than people in a national random sample. In this study, finding five or more different answers from the national data is assumed to be an indication that employees have a different

disposition toward the environment than the national average. Note that there are no "right" or "wrong" answers to the questions and that different is relative to the question asked--different behaviors, different concerns, etc.

As a result of evaluating the survey data[20] and the information gathered during the interviews some general conclusions can be drawn. First, the employees tend to believe that the condition of the environment is getting better. Therefore, they are less worried about the environment than people nationally. They also believe that, in general, business, industry, and the Government all spend too much time worrying about the environment, but that their company is not enough worried. They are keenly aware of the costs associated with environmental compliance and they believe that environmental regulations can go too far. Thus, they are less willing to pay higher taxes or to see job losses because of environmental regulations. They do less volunteer work for environmental groups, but are more likely to voluntarily participate in recycling programs. Finally, almost 70 percent believe that the company strongly supports efforts to prevent pollution and that more time should be spent on environmental issues.

In conclusion, the employees at MDA-E display different views than those found in the national surveys. On balance, they have a more positive outlook on the condition of the environment, are less concerned, and are less likely to consider themselves environmentalists. These views do not seem to translate into an indifference about environmental issues that impact MDA-E or its products, however. There is strong support for the company's pollution prevention efforts and a desire to do more. Thus,

[20]Note that there are three sources of potential bias with the survey results. First, the data collected at MDA-E does not represent a random sample. Second, the questionnaires were distributed in the work place while the national data are from telephone surveys. This biases the definition of "environment," since environment is not defined (it may mean the local environment, national environmental, global environment, etc.). On the questionnaire, respondents appear to assume that several questions are referring to the work place environment. This would not occur in the telephone survey. Finally, there is a bias toward professional and management employees among the respondents. At MDA-E, 90 percent of the respondents identified themselves as managers, engineers, or other professionals.

there is no reason to believe that there is any wide spread negative disposition toward pollution prevention activities that would interfere with implementation of the company's policies.

D.6.3.6 <u>Decision Making and Management Procedures</u>

EA's new strategic planning process incorporates many analytical improvements that will produce better environmental analysis and decisions. Clearly identifying environmental requirements as an input to the use of business case analysis provides much better information for decision making. Other innovations that improve decision making include a new subcontractor rating system that incorporates an environmental component, evaluation of alternatives based on both risk and cost, and new product life cycle costing techniques for evaluating environmental costs.

The new strategic planning process also has a significant limitation, however. The process is constrained by its focus on minimizing the financial impact of environmental directives. This results in a planning process that is compliance driven. Since it is focused on compliance, the EA strategic plan does not directly address MDC's commitments to reduce TRI releases, reduce hazardous waste generation, or other environmental objectives. EA recognizes this, but it is not yet clear what will be done in the next planning cycle.

An important innovation for decision making developed in the short-lived A/F-X program involves the use of comparative baseline studies. When the A/F-X statement of work was released in mid-1990, the environmental portion was very broad and non-specific. As a result, the program team devoted a lot of time to trying to figure out what the Navy really wanted and what the program team would propose. Part of the team's analysis was based on using comparative baseline studies. In the studies, the team took the nearest existing aircraft subsystem for each part of the proposed aircraft and used it to predict environmental impacts and hazardous materials that might result. Based on these

studies, a baseline was developed defining what impacts the best current materials and processes would produce. Once the baseline was in place, metrics for assessing the impact of technological innovations were readily available.

D.6.3.7 Communications

Communicating environmental issues to all levels of management was identified as one of the three specific EA strategies.

> Due to the magnitude of environmental issues facing MDA-E, it is important to accurately communicate the requirements for change, when changes must be implemented, and the areas impacted. . .[21]

The strategic plan is their primary tool for communicating significant environmental issues to management throughout MDA-E. A key method for communicating with the programs is through the product support representatives.

A product support representative with responsibility for environmental issues has been appointed in every program. The representatives are used to coordinate issues between the programs and the core staff.

A major limitation involves access to "black" programs. A black program is a program whose existence is classified. Environmental personnel do not have access, or have very limited access, to many black programs at MDA-E. This is serious limitation and indicates that communications between core functions and the programs needs to be further improved.

The IPD process offers a solution, if it is consistently applied. In addition, the requirements tracking process associated with systems engineering is an excellent vehicle for tracking environmental requirements within a program. The limitation in using this tool has been the lack of clearly identified customer requirements.

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[21]Craig Green, "93 E.A. Strategic Plan Released," Environmental Assurance Newsletter, (St. Louis, MO: McDonnell Douglas Aerospace - East, October 1993) 1.

D.7 Annex to Appendix D -- Text of Contract Pollution Prevention Requirements

D.7.1 F-15 Contract Pollution Prevention Requirements

The F-15 has no contract requirement for pollution prevention.

D.7.2 F/A-18C/D Contract Pollution Prevention Requirements

The F/A-18C/D has no contract requirement for pollution prevention.

D.7.3 F/A-18 Contract Pollution Prevention Requirements

The F/A-18E/F Integrated Logistics Support Detail Specification, 21 April 1992, requires:

> 3.3.7.1.9 Task 401, Task Analysis.
>
> . . . For each operations and maintenance task the following shall be determined: maintenance level; numbers of personnel, skills levels, skill specialties, man-hours, and elapsed time; spares, repair parts and consumables required; support equipment; test, measurement and diagnostic equipment; and test program sets required; training and training material required, along with recommended training locations and rationale; procedural steps required to perform the task; facilities required; interval for and the frequency of task performance in the intended operational environment; and packaging, handling, storage, disposal, and transportation requirements. For unique F/A-18E/F requirements the Contractor shall identify maintenance process resultant waste including the category (air, solid, liquid) of hazardous constituents of waste stream by volume and percent, mitigation measures (to include absolute minimum quantities required for the task) and disposal requirements. Results shall be documented in the Contractor's ILS/LSA data base, retained by the Contractors and made available for Government review upon request.

D.7.4 AV-8B Contract Pollution Prevention Requirements

The AV-8B has no contract requirement for pollution prevention.

D.7.5 T-45 Contract Pollution Prevention Requirements

The T-45 Training System, Integrated Logistics Support Detail Specification for FY-92, 16 June 1992, requires:

6.2.4 HAZMAT/HAZWASTE/POLLUTION Task Identification and Analysis To ensure the undelayed manufacture, operation and maintenance of the T-45, the program must comply with the most stringent of International, Federal, State, and Local laws and regulations that apply to those sites the T-45 is manufactured, operated or maintained ashore or afloat. The contractor shall, to the maximum extent possible, incorporate materials that are environmentally compliant or its use is controlled such that it will meet those laws and regulations. Hazardous material is defined as any material that is (1) regulated as a hazardous material in accordance with 49 CFR 173.2, or (2) requires a Material Safety Data Sheet (MSDS) in accordance with 29 CFR 1910.1200 or (3) during use, treatment, handling, packaging, storage, transportation, or disposal, meets or has components which meet or have potential to meet the definition of a hazardous waste as defined by 40 CFR 261, subpart A, B, C, or D.

This effort shall include but is not limited to identification of the functional requirements of hazardous material, hazardous waste and environmental pollutants associated with the operation, maintenance and support functions of the T45TS Include in the identification any hazardous cleanup materials or hazardous cleanup wastes generated as a normal result of the task being performed.

Perform a detailed analysis of these identified tasks to determine the environmental law compliance requirements. Utilize actual manufacturer's information such as an MSDS when analyzing the materials used in a task. For those military standards that have more than one qualified produce available, determine and use the worst case product for the analysis. This is required because two different products for the military standard may have different constituents.

The analysis of scheduled and unscheduled maintenance actions will be for on-aircraft and off-aircraft maintenance.

Identify those requirements which are unique to the system/equipment due to new design technology or operational concepts or which are supportability, cost, or readiness drivers. This includes the identification of new resources/technologies which require development within the next 5 years to ensure undelayed manufacture, operation and maintenance of the T-45A.

6.2.4.1 Task Inventory. A task inventory shall be prepared identifying these requirements and shall be composed of but is not limited to; Task descriptions in accordance with MIL-STD-1388-1A.

6.2.4.2 Identification. Identification of the hazardous material, hazardous waste or pollutant which consists of:

a. Nomenclature, manufacturer's part number and military specification if applicable for hazardous material

b. 40 CFR 261 waste code number and nomenclature of hazardous waste

c. Estimated quantity of material usage or waste/pollutant generated per task. Include an estimated spillage quantity of 20% over the estimated quantity usage not to exceed 0.5 pints total per task. If a material is used up in the task state so.

6.2.4.3 Summary. Summarize each generated waste stream as follows:

a. Quantity of hazardous waste generated per year

b. Cost of disposal, abatement or mitigation being performed for each stream per year

c. Identify and list all new or critical support resources associated with the use of hazardous materials, hazardous waste or environmental pollutants. This will include any cost, supportability or readiness drivers.

The task inventory identification and summary shall be developed in contractor format.

6.2.4.4 HAZMAT/HAZWASTE/POLLUTION. Alternatives and trade-off analysis.

6.2.4.5 Purpose. To determine the preferred alternatives to materials and processes that have an environmental impact or due to environmental laws and regulations is a cost, readiness or supportability driver; and to participate in alternative system trade-offs to determine the best approach (support, design and operation) which satisfies the need with the best balance between cost, schedule, performance, readiness, and supportability.

6.2.4.6 Processes. The following processes are identified to be cost drivers due the current escalating costs incurred in procurement of hazardous materials, hazardous waste disposal or other environmental impact.

a. Ozone depleters used in cleaning (such as but not limited to Freon 113 and 1,1,1-trichloroethane)

b. High VOC Topcoat paints and primers used to paint aircraft exterior and components

c. Chemical paint stripper (Methylene Chloride) used to remove entire aircraft paint systems

d. Cadmium plating used to coat steel components.

6.2.4.6.1 Evaluation. Evaluate these processes for annual cost and supportability to include but not limited to the following current and projected considerations:

a. Cost of material per task
b. Availability of material
c. Cost of manpower per task
d. Elapsed time for process
e. Cost of energy
f. Cost of abatement
g. Cost of waste disposal
h. Cost of mitigation.

6.2.3.6.2 Procedures. The following procedures are possible alternatives to the potential cost drivers:

a. Detergents, such as but not limited to, MIL-C-85570 authorized in NA 01-1A-509, Cleaning and Corrosion Control Manual, instead of ozone depleters

b. UNICOAT TT-P-2756 instead of primer and high VOC topcoat

c. Plastic media blast, Carbon Dioxide blast and Benzyl alcohol as separate alternatives to chemical paint remover such as methylene chloride

d. Ion Vapor Deposited aluminum instead of cadmium plating.

6.2.4.7 Alternative Processes. Evaluate these alternative processes for annual cost and supportability to include, but not limited to, the following current and projected considerations:

a. Cost of material per task
b. Availability of material
c. Cost of manpower per task
d. Elapsed time for process
e. Cost of energy
f. Cost of abatement
g. Cost of waste disposal
h. Cost of mitigation.
i. Cost of additional test and evaluation
j. Cost of start up (equipment, training, etc.)

k. Time for return on investment

6.2.4.7.1 Documentation. HAZMAT related alternative trade-off analysis for all evaluation items shall be documented in contractor format. (CDRL J00R)

D.7.6 A/F-X Contract Pollution Prevention Requirements

The AX Weapon System, Concept Exploration, Statement of Work required:

102.7 ENVIRONMENTAL EFFECT The contractor shall develop and deliver an environmental effects plan that describes 1) the approach to reduce and minimize hazardous waste, air, and water emissions through use of less hazardous materials and processes in the development, design, support, and maintenance of the weapon system; 2) the approach to minimize the adverse impact to endangered species and habitat with the development, manufacture, operation and support of the weapon system; 3) the impact to the environment associated with the manufacture, operations and maintenance of the system to all applicable site and areas the system is maintained and operated. The plan shall also address hazardous materials abatement, facilitization, mitigation, and disposal considerations, both ashore and afloat. During the design tradeoff process, specific emphasis shall be on elimination of hazardous materials that would require reapplication during O/I/D maintenance. Those materials that generate hazardous waste during maintenance shall also receive special emphasis to minimize their use. This plan shall be provided as part of the contractor's ILS Management Plan.

APPENDIX E
CASE STUDY AT PRATT & WHITNEY
Government Engines & Space Propulsion, West Palm Beach, Florida

F119 and F100 Jet Engines

E.1 Introduction

Pratt & Whitney (P&W), a division of United Technologies Corporation, is a leading designer and builder of high-performance jet engines for commercial, military, and general aviation. The Government Engines & Space Propulsion (GESP) unit, located in Palm Beach County, Florida is responsible for military gas turbine engines, liquid rocket engines, sold rocket motors and space launch services. The GESP facility was opened in 1958 and is located in the western portion of the county, on the edge of the Everglades.

The Florida-based GESP staff design, develop, test, market, and support P&W military gas turbine engines. All military and commercial engines are manufactured by P&W's Operations unit, headquartered in Connecticut. Solid-fueled rocket motors are produced at GESP's facility in San Jose, California. The liquid hydrogen-fueled RL-10 rocket engine is produced at the Palm Beach County, Florida facility.

In addition to the F119, being developed to power the Air Force's F-22 Advanced Tactical Fighter, GESP is also responsible for the F100 family of engines that power the Air Force's F-15 and F-16 fighter jets; the F117, a military version of P&W's PW2000 series engine used on the new C-17 cargo plane; the J52 engine that is installed in Navy and Marine Corps A-6 Intruder, EA-6B Prowler, and A-4 Skyhawk aircraft; the RL-10

rocket engine that powers the upper stage of the Atlas-Centaur and Titan-Centaur launch vehicles; and the space shuttle's main engine alternate turbopumps.

E.2 Case Study Organization

The remainder of the case study is organized into six major sections: 1) Program Overview, where general background information is provided for each program included in the study; 2) Corporate Background, where information on the parent corporation is presented; 3) Data Gathering, which provides information on how and when the study data were collected; 4) Results and Analysis, where the details of the case are presented; 5) Summary; and 6) Text of Contract Pollution Prevention Requirements.

The heart of the case study, the Results and Analysis section, begins with a presentation of the relevant program contract requirements and corporate policies. The section continues with the organizational setting, features of the pollution prevention program, the corporate environmental record, and pollution prevention results. The final portion of this section includes a separate analysis on each of seven different implementation factors.

E.3 Program Overview

This case study is primarily concerned with the F119 engine that is under development. The F100 engine program is used primarily as a baseline for comparison with the F119 program. The current status of both programs is summarized in Table E.1.

Engine	Acquisition Phase	Contract Pollution Prevention Requirements
F119	Engineering & Manufacturing Development	Extensive Hazardous Materials Program
F100	Production	Hazardous Materials Used During Repair

Table E.1. Program Status Summary

E.3.1 F119 Jet Engine

The Pratt & Whitney (P&W) F119-PW-100 jet engine was selected in April 1991 in a competition with a General Electric engine to power the Air Force's F-22 fighter. The F119 is an augmented turbofan engine, in the 35,000 pounds of thrust class, that incorporates advanced composite materials, a two-dimensional thrust vectoring nozzle, digital electronic controls, and fewer parts than engines in the preceding *F100 engine* family.

F119 engine development began in 1983 with the XF119 demonstrator engine program. The YF119 prototype engine program followed in 1986 and led to the development of the Demonstration/Validation engines that flew in the YF-22 and YF-23 prototypes. The engine is currently in Engineering and Manufacturing Development (EMD) and has completed its critical design review. EMD is scheduled to continue into 2000, resulting in a development time of over 15 years. The Production phase of the program will begin following EMD.

The EMD contract calls for P&W to eliminate the use of hazardous materials where possible and to mitigate the consequences of using hazardous materials as appropriate.

E.3.2 F100 Jet Engine

Almost 6000 F100 engines have been produced since their initial operational introduction in 1974. The operational version, the F100-PW-100, was developed for the Air Force F-15 fighter. In 1978, the F100-PW-200 engine began service in the F-16. Over the years the engine has been continually improved. In 1985, the F100-PW-220 was introduced for use in both the F-15 and the F-16. The current production version is the F100-PW-229. The F100-PW-100 is a 24,000-pound thrust afterburning turbofan engine. The "229," provides 29,100 pounds of thrust, a nearly 30 percent increase. In addition, each follow-on engine in the F100 family has demonstrated greater reliability than its predecessor.

In the environmental area, current F100 contracts address hazardous materials used in repairing the engine. Engine noise and smoke emissions are addressed in detail; however, the requirements are largely based on operational survivability concerns.

E.4 Corporate Background

United Technologies is a large holding company with assets in four primary business areas: power, flight systems, building systems, and automotive. The companies that make up each business area together with their 1992 financial results are shown in Table E.2.

Business Area	Revenues		Operating Profits
Power Pratt & Whitney Pratt & Whitney Canada	$6.94 billion	32%	$(305) million
Flight Systems Sikorsky Hamilton Standard USBI/Chemical Systems Norden	$3.98 billion	18%	$298 million
Building Systems Otis Carrier	$8.84 billion	40%	$465 million
Automotive UT Automotive	$2.38 billion	11%	$111 million
Other	$(0.10) billion		$20 million
United Technologies (Totals)	$22.03 billion		$589 million

Table E.2. United Technologies Revenues and Operating Profits for 1992

After taxes and other charges are considered, United Technologies had a net loss of $287 million in 1992. This followed a net loss of $1.02 billion in 1991. Following the 1991 loss, United Technologies announced a major restructuring intended to eliminate more than $1 billion in annual operating expenses by the end of 1994. Pratt & Whitney (P&W) accounted for a large part of the losses due to the slump in the worldwide airline industry and the reduction in defense spending. As a result of the restructuring now under way, P&W will be a permanently smaller aircraft engine maker.

Under the first restructuring plan announced in early 1992, P&W was to cut 5,000 jobs from its work force of 41,000 by the end of 1995 and was to shrink its manufacturing space by 3.1 million square feet. A year later, the plan called for cutting 11,000 jobs by the end of 1994. If achieved, this will reduce P&W's work force below 30,000.[1]

P&W's Palm Beach County operation on was established in 1958 to design and test military jet engines and space propulsion systems. Today, Government Engines and Space Propulsion (GESP) serves as P&W's primary development center for military jet engines. GESP hosts each program's technical staff, an operations staff that custom builds development and test engines, and extensive engine test facilities.

E.5 Data Gathering

Information for this case study was obtained during a seven-day visit to GESP in September 1993. During the site visit, the investigator interviewed seventeen people, attended two integrated product development team meetings, observed engine testing and development facilities, and distributed 71 questionnaires that were completed by P&W personnel. The visit was sponsored by P&W and the Air Force's F-22 program office.

E.6 Results and Analysis

E.6.1 Policy Framework

E.6.1.1 Corporate Environmental and Pollution Prevention Policies

P&W's parent organization, United Technologies Corporation, (UTC) has traditionally delegated environmental responsibilities to the major operating units, keeping the central staff small. This situation is changing, but in the area of pollution prevention,

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[1]Even with the reductions, P&W had a 48% share of the world-wide new orders for large commercial engines in 1992. Within the power area, the commercial engine market accounted for 54% of the revenue, the government (military and space) market 29%, and general aviation 17%. P&W competes commercial and government markets while P&W Canada competes in the general aviation market.

there is no overall UTC policy statement. The corporate staff has taken several important steps, however. In 1991, UTC committed the corporation to meeting the voluntary chemical release reduction goals in EPA's 33/50 Program. In addition, UTC has set several other corporate-wide pollution prevention goals. Notwithstanding this recent activity, P&W and the other units continue to operate more-or-less independently, establishing their own environmental policies.

A P&W Group Standard on pollution prevention was issued on 15 December 1992. The standard establishes company policy along with a minimum framework for developing management systems at each facility that include site-specific policies and procedures. The company policy on pollution prevention states:

> Pratt & Whitney will meet all federal, state, and local requirements associated with pollution prevention by creating and maintaining a system. The goal of the system is to prevent the generation of waste.[2]

To achieve the desired management system at each site, the standard sets minimum requirements in three broad areas: 1) identifying, quantifying, and tracking all hazardous materials and wastes, 2) developing and maintaining pollution prevention plans, and 3) ensuring all process changes and new processes are reviewed for environmental impacts as early in the planning stages as possible. Specific pollution prevention training is included as an optional component.

UTC & P&W pollution prevention goals are listed in the standard's appendix. Table E.3 lists the current UTC and P&W pollution prevention goals.

The Minnesota Guide to Pollution Prevention Planning, written by Terry Foecke,[3] a leader in developing pollution prevention implementing strategies, states that a pollution prevention policy statement should provide a clear understanding of, 1) why a pollution

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[2]Pratt & Whitney, "Pollution Prevention Management System," Environment, Health, and Safety Group Standard Number 1.0, (East Hartford, CT: Pratt & Whitney, 15 December 1992), 1.

[3]Terry Foecke and Al Innes, Minnesota Guide to Pollution Prevention Planning, (St. Paul, MN: Minnesota Office of Waste Management, 1992) 2-1.

prevention program is being implemented, 2) what will be done, and 3) who will do it. The P&W standard describes what will be done, but fails to describe why the program is being implemented and who is responsible for implementation. The policy paragraph of the standard, which is quoted above, is so general and vague that it is nearly meaningless when read in context, and is completely meaningless as a stand-alone policy statement.

Goal	UTC	P&W
Base Year	1988	1988
Target Year	1995	1995
% Toxic Air Reduction	50	85
% Process Hazardous Waste Reduction	50	80
% Reduction in EPA 33/50 Program 17 Chemicals	50	50

Table E.3. United Technologies Corporation and Pratt & Whitney Pollution Prevention Goals

In addition to its pollution prevention management policy, P&W also has a policy on reducing the use of volatile halogenated chemicals. The policy requires eliminating the use of all volatile halogenated chemicals from facility and product operations and it establishes target dates for different classes of chemicals. Volatile halogenated chemicals are defined to be any volatile organic chemical that contains one of more of the halogens: fluorine, chlorine, or bromine. The standard does not apply to acids such as hydrochloric acid or to waste treatment chemicals such as chlorine and sodium hyprochlorite.

E.6.1.2 Government Pollution Prevention Requirements

The F119 EMD contract requires P&W to conduct a hazardous materials program (HMP) as described in section 6.1.12 of the contract statement of work (SOW).[4] The SOW requires P&W to, "develop, maintain, update, and implement a hazardous materials

[4]Pratt & Whitney, "F119 FSD Statement of Work", (Wright-Patterson AFB, OH: Aeronautical Systems Division, 7 March 1991), Section J, Attachment 1 to contract number F33657-91-0007.

program." The program is to, "focus on the elimination of hazardous materials where possible or mitigation of consequences as appropriate." The complete text of section 6.1.12 of the SOW is provided at the end of the case study in section E.7. The contract requirements are summarized in Table E.4.

Program	**Contract Requirements**
F100	- Hazardous materials used during repair of the "229"
F119	- Identify and control hazardous materials --Develop and implement a Hazardous Material Program Plan --Submit data on hazardous materials to the Government --Record decisions on hazardous material uses

Table E.4. Summary of Pollution Prevention Contract Requirements

In response to the SOW requirements, P&W's developed and submitted to the Air Force a Hazardous Materials Program Plan (HMPP) that describes how the company intends to meet the contract requirements. According to the HMPP,

> The purpose of the Hazardous Materials Program (HMP) is to influence the F119 engine design to reduce the environmental, life cycle cost, and liability impact of HM while maintaining a balance between design parameters, such as repairability, and supportability.
>
> The objective of the HMP is to identify, document, and/or eliminate/substitute/ mitigate/minimize all applicable (Section 1.2) hazardous materials through the life cycle of the F119 EMD Program.[5]

The above reference to Section 1.2 refers to the scope section of the HMMP.

Under this section, the HMP only applies to,

> . . . Hazardous materials intrinsic to the F119 engine end items at delivery to the Air Force, and hazardous materials identified in the operation, repair, maintenance, support, mishaps, and disposal of the F119 engine. . . These hazardous materials will be referred to as "applicable hazardous materials". . .

[5]United Technologies, Pratt & Whitney, F119-PW-100 Engineering and Manufacturing Development Program, "Hazardous Materials Program Plan," prepared in response to Contract F33657-91-0007, CDRL A001, Data Item Description OT-90-34207, (Wright-Patterson AFB, OH: Aeronautical Systems Division, 6 March 1992), 2.

> Hazardous materials that are part of the manufacturing process of the F119 EMD program end items will be covered by Pratt & Whitney's internal hazardous material and waste minimization efforts.[6]

The practical impact of Section 1.2 is to limit the scope of what must be reported to the Air Force. This was done to limit government review of decisions that have historically been made by the contractor and to reduce reporting requirements. Internally, the same evaluation procedures are used for all hazardous materials, whether they are applicable hazardous materials or are only using during the manufacturing process.

In addition to the hazardous materials requirements, the F119 prime item development specification (PIDS) contains a host of performance criteria that directly impact the environment. These requirements are driven by operational, logistics, and safety concerns. The requirements include quantitative limits for emissions of oxides of nitrogen and require testing to determine emissions of nitrogen oxides, carbon monoxide, and hydrocarbons; limits for smoke emissions; limits on leakage rates from the fuel system, oil system, and hydraulic system; and they prohibit the use of specific materials in certain applications. Compliance with these and other PIDS is verified during the engine testing program. For example, during engine tests all external leakages are collected, measured, and reported so that five separate leakage limits can be verified. For the fuel system, overboard drain leakage must be less than five cubic centimeters per minute with the engine running and less than ten drops per hour at cutoff. In addition, static and dynamic leakage from any fuel system source other than the overboard drain, must be less than one drop per hour. Similar limits apply to the oil and hydraulic systems.

The draft SOW requirements for the HMP were structured by the program office and the contractor with help from the staff of the Aeronautical Systems Center (ASC), System Safety Office. The staff had access to the Pollution Prevention Act of 1990 and to draft copies of DoD and Air Force pollution prevention policies that indicated the general

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[6]Ibid., 1.

direction that policy was moving. Within this very general framework, the ASC staff developed a draft statement of work and the data item descriptions (DIDs). The key staff consisted of system safety and bioenvironmental engineers. The staff's proposed HMP requirements were accepted by the program manager with little comment. The HMP requirements were then included in the draft SOWs for both the F-22 and F119. The contracting method used for both contracts allowed the contractors to write the final SOW. Thus, the final SOWs differ, but the both include the same Data Item Descriptions, requiring the same information be reported to the program office.

E.6.2 Organizational Setting and Scope of Pollution Prevention Activities

E.6.2.1 Organizational Setting

The F119 program is managed at P&W's Government Engines & Space Propulsion (GESP) unit in Florida. Support is provided by a number of P&W functions located in Connecticut. The important relationships for pollution prevention are shown in Figure E.1. The functions shown on the right side of Figure E.1 are located in Connecticut. Those on the left side are located at the GESP facilities in Palm Beach County, Florida.

Important company functions located in Connecticut include engineering, operations, and environmental policy. Guidance on engineering and materials issues are provided by organizations that report to the Technical Operations Executive Vice-President. All production engines are manufactured by Operations personnel and P&W environmental, health, and safety policies are set by the Vice-President for Environment, Safety, and Health.

At GESP, facility type environmental issues are handled by the Environmental Affairs Group. The group reports through the Facilities and Environment Manager to the GESP President. The group get its functional guidance from the company's Environment, Safety, and Health organization.

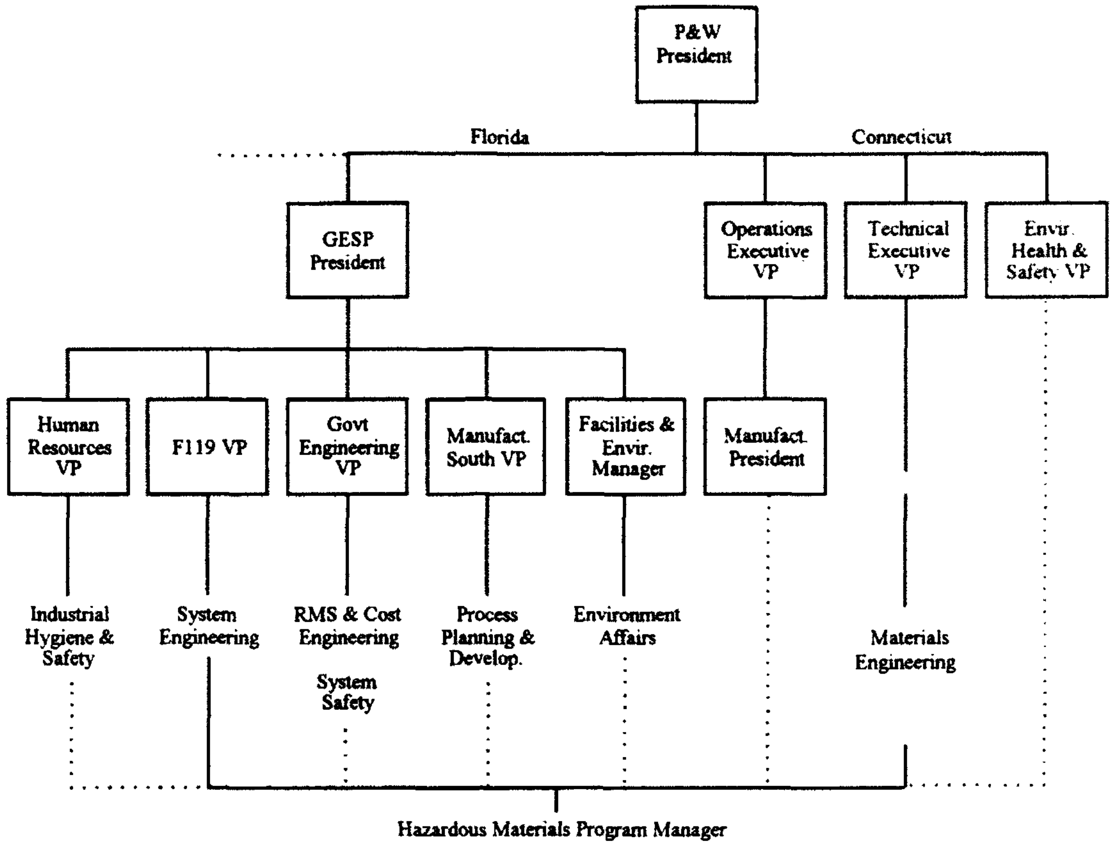

Figure E.1. Partial P&W Organizational Chart

The F119 program uses a matrix-type organization, drawing staff from the various functional areas. The F119 HMP manager reports program issues through the F119 Systems Engineering Manager and functionally through Materials Engineering. Hazardous material design issues are a Materials Engineering responsibility. Materials Engineering is a part of the Technical Operations Organization. The HMP is responsible for implementing the HMP and is the single point of contact for external organizations on hazardous material pollution prevention issues. The HMP manager has the authority to interface with all integrated product teams (IPTs) and groups within the program and has access to personnel up or down the organization chain.

On a day-to-day basis within the F119 IPTs, each functional area representative is responsible for the environmental issues assigned to the function. For example, Repair

Design Engineering is responsible for the design of repair procedures included the use of hazardous materials, and Design Metallurgy is responsible for material and process specifications, including hazardous material minimization sign-off on all engineering task requests (ETRs) . ETRs are work request forms authorizing and funding each design task. The Design Metallurgy IPT representatives also provide a day-to-day interface between the IPTs and the HMP manager.

E.6.2.2 Pollution Prevention Program Scope and Key Features

The P&W Hazardous Material Program (HMP) is composed of three major tasks: hazardous material reduction, hazardous material tracking, and subcontractor management.[7]

Hazardous material reduction involves the, "elimination/substitution/minimization/ mitigation of all applicable hazardous materials by providing input, guidance and control into the design and development process up front."[8] This is accomplished using several management processes and procedures. Specific steps include the use of integrated product teams (IPTs), the P&W Charter Parts Council, and the design review process.

Each F119 integrated product team (IPT) is responsible for the hazardous material content of its portion of the design. To aid the IPTs in implementing this task, the HMP objectives, guidelines, and training for material selection were presented to the IPT members. Within each IPT, the materials engineering representative serves as a technical expert and as an interface between the IPT and the HMP manager.

The P&W Charter Parts Council provides each team with a set of design norms. These norms provide guidelines for the preferred design, configuration, material selection, and manufacturing process for a specific type of part. The IPTs are required to follow the design norms, but deviations are allowed using a waiver process if an IPT has good

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[7]Ibid., 2.

[8]Ibid., 13.

reasons for not following a norm. The Charter Parts Council is a P&W company-wide function and its norms apply to commercial as well as military engines. A guidance document on environmental design considerations was provided to the Charter Parts Council in June 1992. The guidance provides a consistent set of environmental considerations to be addressed by each Charter Parts Council working group.

The final element in P&W's hazardous materials reduction strategy involves using the design review process to assess and obtain control of the amount and type of hazardous materials contained in a design; used in production; or used in repair, maintenance, or support of an engine component. Implementation of the revised review process was accomplished by modifying two internal engineering procedures: the Engineering Task Request (ETR) and Standard Procedure N-8, Hazardous Waste Minimization. The Engineering Task Request is used to authorize and track all design tasks. One of requirements necessary for completing an ETR is "sign-off" on the final design by the IPT and various support functions. Among the IPT's responsibilities are hazardous materials and hazardous waste minimization. ETR procedures assign responsibility for certifying that, "all possible efforts have been made for elimination, substitution, mitigation, and minimization of hazardous materials and hazardous waste,"[9] to the IPT's Design Metallurgy representative. Design Metallurgy is a part of the Materials Engineering organization. Special Procedure N-8 describes Design Metallurgy's hazardous material minimization responsibilities in detail. Together, these procedures firmly task each IPT with hazardous materials minimization, and specifically task Design Metallurgy with certifying that company hazardous material and hazardous waste minimization policies have been implemented.

The second element of P&W's HMP is hazardous material tracking. Tracking is accomplished using a hazardous material data base (HMDB). The HMDB incorporates

[9] Ibid., 14.

information from the Engine Product and Configuration Support (EPACS) data base and the Logistic Support Analysis Record (LASR). The EPACS includes information on all engine end-items and the LASR covers all repair, maintenance, and support process materials. Together, the combined information covers all applicable hazardous materials except production materials, which are tracked separately. Technical information on each hazardous material is taken from its material safety data sheet (MSDS).

Subcontractor management is the third element of the HMP. This task involves incorporating the key elements of the HMP into P&W's subcontracts. Specifically, subcontractors are tasked to identify and document all hazardous materials present in an engine component end item or needed in the repair, maintenance, or support of the item. For the F119 program, this is being accomplished using a hazardous material management clause in the Purchasing and Procurement Specification.[10]

The hazardous material management subcontractor specification flows the tasking to identify hazardous material on to Pratt & Whitney's subcontractors, but does require any

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[10]Mike Gehron, Pratt & Whitney Hazardous Material Program Manager, "Hazardous Materials Program," speech and handouts presented at the F-22/F-119 Environmental Working Group. Wright-Patterson AFB, OH, 17 June 1992. Text of F119 subcontractor hazard materials management clause:

> The subcontractor shall develop, maintain, update, and implement a Hazardous Materials Program (HMP). Through the HMP, all Hazardous Materials (HM) intrinsic to an F119 end item (component) or used in the repair, maintenance, or support of an F119 end item. through the life cycle of the program, will be identified and documented. Hazardous Materials which are part of the manufacturing processes shall not be considered, however, these materials should be managed as directed by the current local, state, and federal environmental regulations.
>
> Pratt & Whitney will provide the subcontractor with the Aeronautical Systems Division (ASD) Priority Hazardous Materials List (attached) and subsequent updates. The subcontractor will use the ASD prioritized list and any current local, state, and federal regulations as a guide for identification of HM. Notification and certification to the Pratt & Whitney Subcontractor Manager is required if a HM is or is identified. If a HM is identified Pratt & Whitney and the subcontractor will coordinate efforts to eliminate / substitute / mitigate / minimize its use. Upon agreement of the HM disposition. the subcontractor shall document the HM and provide Pratt & Whitney a Material Safety Data Sheet (reference: contract clauses 252.223-7004 DFARS and 52.223-9000 AFSC FAR SUP) for each HM identified. This information shall be provided to the Pratt & Whitney Subcontractor Manager by 30 June 1992. Certification of the presence or absence of HM is required. Updates required as applicable.

specific hazardous material minimization efforts. In addition, there is no tasking requiring the subcontractors to task their subcontractors.

E.6.2.3 Corporate Record on Environmental Issues

On 24 August 1993, The New York Times and The Wall Street Journal reported that United Technologies settled a series of environmental violations for $5.3 million. Quoting information from the U.S. Environmental Protection Agency and the Department of Justice, the article states that, "$3.7 million of the fine was levied under the federal Resource, Conservation and Recovery Act and is the largest civil penalty ever imposed under the law."[11] The remaining $1.6 million of the fine was imposed for violations of the federal and state Clean Water Acts.

The settlement stemmed from a Federal lawsuit filed in September 1990 for violations that included unauthorized discharges, including the dumping of acid that resulted in a fish kill in the Quinnipiac River; discharging waste water that was not adequately treated into a publicly owned treatment plant; improper handling of hazardous waste; storing hazardous waste without a permit; inadequate record-keeping; and inadequate training. The violations occurred at seven Pratt & Whitney plants and at several other United Technologies facilities in Connecticut.

The New York Times reported on a news conference where,

> Paul G. Keough, the acting regional administrator for the Environmental Protection Agency, said United Technologies had 'perhaps the worst environmental record of any company' in New England. That record led to a separate $3 million criminal penalty in 1991, then the largest criminal fine in United States history for violating hazardous waste laws.[12]

United Technologies officials stressed that the company had changed its ways.

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[11]Amal Kumar Naj, "United Technologies Fined $5.3 Million for Series of Environmental Violations," Wall Street Journal, 24 August 1993, B6.

[12]New York Times, "United Technologies to Pay Fines of $5.3 million in Pollution Case." 24 August 1993, Section B, 4.

> In agreeing to pay the fines, United Technologies Chairman Robert F. Daniell said, "The attitudes and practices that led to these violations were unacceptable, and we have moved aggressively to change them." . . .
>
> As part of the settlement with the government, the company also agreed to undergo extensive audits of its environmental practices until the end of the decade. . .
>
> Mr. Daniell acknowledged in a letter to employees following the government action that employee training for environmental awareness and compliance at the company hasn't been adequate. Urging more employee involvement, he said, "There should be no need for further wake-up calls from the government."[13]

By the time the final settlement was reached, the changes called for in the agreement were already well into implementation, including the establishment of an environmental auditing program with EPA oversight.

United Technologies has be cited for environmental violations in other states as well. In January 1992, the Chemical Systems Division in San Jose, California was cited for improperly characterizing and storing hazardous waste and for conducting open burning of waste rocket fuel. The complaint was settled in February 1993. Under the agreement, United Technologies paid a penalty of $165,000 and agreed to reduce the amount of hazardous waste generated at the facility.[14]

In July 1992, the Maine Department of Environmental Conservation filed an administrative consent agreement alleging that the employees were not trained to ensure compliance with hazardous waste rules and that the North Berwick Pratt & Whitney facility did not meet the effluent limitations of its water discharge permit. The issue has not been settled.[15]

Also in 1992, United Technologies Automotive Systems paid $229,500 in penalties to the Michigan Department of Natural Resources for exceeding permit-mandated air

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[13]Naj, B6.

[14]US Securities and Exchange Commission, "United Technologies Corporation 10-Q Report," (Washington D.C.: US Securities and Exchange Commission, 30 September 1993), 24-25, Commission File Number 1-812.

[15]Ibid., 25.

emissions levels and for violating Michigan Air Pollution Controls rules on record keeping.[16]

Evidence that the regulators have gotten the attention of top management is obvious in Chairman Robert Daniell's comments in Directors & Boards in 1991:

> The regional Environmental Protection Agency (EPA) administrator, in announcing environmental violations at several of our Connecticut locations said, "There have been violations in the past. They haven't set in motion a process to make sure there is continual compliance. So, we have to assume that they have not taken their corporate environmental responsibilities very seriously."
>
> Those are not words a board member, or an employee, or a resident of our plant communities wants to hear. And they most certainly were not the words I, as CEO, want to hear. But such comments--and the fines and warnings that accompanied them--spurred us to redouble our environmental efforts.[17]

Additional evidence that the regulators have gotten the attention of top management can be seen in the increasing prominence of environmental issues in United Technologies Corporation's (UTC) last three annual reports. In 1990, a short statement appeared near the end of, "Management's Discussion and Analysis of Results of Operations and Financial Position," section of the annual report describing potential environmental liabilities:

> The Corporation has operations in several lines of business which involve the use, treatment, storage and disposal of substances regulated under various environmental protection laws. In the regard, the Corporation had expenditures related to environmental matters of $86 million in 1990 and $75 million in 1989. Expenditures are expected to range between $100 million and $150 million in each of the next two years.
>
> In addition, the Corporation is a potentially responsible party at approximately 100 sites, many of which related to formerly-owned businesses. . .[18]

A shorter version of the same statement also appeared in the, "Notes to Financial Statement." In the 1991 annual report, a similar acknowledgment of contingent liability

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[16] Ibid.

[17] Robert F. Daniell, "Remolding the Environmental Function," Directors & Boards, (Summer 1991): 15.

[18] United Technologies Corporation, "1990 Annual Report," (Hartford, CT: United Technologies Corporation, 1991) 34.

for cleanup again appeared in the "Notes to Financial Statements," but a more detailed statement on environmental restoration activities was added in, "Management's Discussion and Analysis:"

> In late 1990 and continuing into 1991, the Corporation dramatically heightened its focus on, and devoted substantive resources to, addressing environmental remediation matters and to minimizing hazardous waste generation. Throughout the period, the Corporation engaged environmental engineering consultants to assist with preliminary studies and assessments of the Corporation's operating sites to ascertain the nature and extent of environmental remediation activities required to mitigate existing contamination. Those studies and assessments provided the basis for developing estimated costs for environmental remediation activities and for a related fourth quarter pre-tax charge to operations of $256 million, principally impacting the Power and Flight Systems segments.[19]

By 1992, environmental issues were discussed on page 4 in the opening letter to shareholders from the Chairman, Robert F. Daniell and the President, George David:

> Among other issues affecting United Technologies, we has seen meaningful results from the corporation-wide environmental initiatives begun in late 1990. In 1992, UTC reported to the U.S. Environmental Protection Agency a decrease of nearly 50 percent, or about 5.36 million pounds, in noxious air emissions, compared to the 1988 base year.
>
> In addition, specialized environmental training was provided to more than 500 line managers, environmental professionals, and technicians as part of a continuing process of reinforcing responsibilities for environmental compliance at all levels of the corporation. This training is now being extended to our non-U.S. companies.[20]

In addition, the 1992 annual report states that 1991 environmental expenditures were $57 million and in 1992 were $82 million. The environmental spending profile presented in the annual reports is shown in Table E.5.

The table shows spending for environmental activities has actually decreased from its high of $86 million in 1990 and that projections in the annual reports that spending would increase to between $100 and $150 million were incorrect.

[19]United Technologies Corporation, "1991 Annual Report," (Hartford, CT: United Technologies Corporation, 1992), 23.

[20]Robert F. Daniell and George David, "1992 Annual Report," (Hartford, CT: United Technologies Corporation, 1993) 4.

Year	(millions)
1989	$75
1990	$86
1991	$57
1992	$82

Table E.5. United Technologies Corporation Environmental Expenditures

While United Technologies as a whole, and Pratt & Whitney (P&W) in particular, were struggling with the EPA over regulatory compliance issues the last several years, operations at GESP in Florida have been relatively free from regulatory problems. With the exception of some on-site clean-up of old ground water contamination, GESP has a good environmental record according to state environmental regulators. [21]GESP has been inspected at least once per year over the past five years and no enforcement actions have been needed. This is a marked contrast to P&W's operations in Connecticut.

This success at GESP is probably due to a strong environmental management effort at the local level together with a long history of water quality concerns in south Florida and a different organizational culture at GESP. Part of the reason for the different organizational culture is that GESP is a research and development (R&D) center, not a production center. For environmental management, this means that the nature of the waste management task is much different. Waste volumes are relatively small but the characteristics of the wastes change based on the nature of the R&D taking place. This is in contrast to a production operation for jet engines where the nature of the waste streams is relatively constant and waste volumes are large.

Given the variability of the waste streams at a research and development facility, it is difficult to manage wastes by employing standard operating procedures. Instead, active

[21]Jeff Smith, Florida Department of Environmental Protection, telephone interview by author. Southeast Florida Sub-District Office, West Palm Beach, Florida, 27 September 1993.

management is required to continually assess the wastes being produced and to manage disposal. GESP's success in meeting compliance requirements is a good indication that the unit has a history of strong leadership in the environmental area and a well trained staff. This view is supported by the fact that P&W's current Vice-President for Environment, Health and Safety was recently promoted to the position from GESP.

Environmental releases at GESP are reported in the facility's Toxic Inventory Release (TRI) reports. Current EPA criteria require facilities that use more than 10,000 pounds of a TRI chemical per year to submit an EPA Form R on each chemical that exceeds the threshold. A summary of GESP's TRI data from 1988 through 1992 is shown in Table E.6.

Bold Chemicals are part of the EPA 33/50 Program
(All Figures are Total Chemical Releases in Pounds)

Chemical	1988	1989	1990	1991	1992
Ammonia	36,040	25,030	8,741	7,215	7,040
Chromium Compounds	0	250	5	0	0
Cobalt	0	250	0	0	0
Hydrochloric Acid	3,800	2,100	2,147	425	140
Nickel Compounds	0	250	5	5	0
Nitric Acid	250	1890	268	451	98
Trichloroethylene	85,000	84,200	81,920	66,298	50,300
33/50 Program Releases	85,000	84,700	81,930	66,303	50,300
	--------	--------	--------	--------	--------
Total TRI Releases	125,090	113,970	93,081	74,394	57,578

Table E.6. Summary of GESP Toxic Release Inventory (TRI) Reports
From 1988 through 1992

The figures shown represent total releases reported on the Form R. The figures do not include quantities used for energy recovery, quantities recycled,[22] or quantities treated.

[22]Note that large quantities of chromium and nickel are recycled off-site and are not shown as releases. In 1992, GESP recycled 79,000 pounds of chromium and 170,000 pounds of nickel. This down from 166,727 pounds of chromium and 305,675 pounds of nickel in 1991.

The data in Table E.6 was taken from copies of the EPA Form R reports maintained at GESP.[23]

GESP, along with the rest of United Technologies, is a voluntary participant in the EPA's 33/50 Program, which calls for reduction of the releases in seventeen chemicals by 33 percent by 1993, and 50 percent by 1995 based on a 1988 baseline. GESP's 1988 baseline for EPA's 33/50 Program is 85,000 pounds and includes their chromium, nickel, and trichloroethylene releases. For 1992, the most recent year available, GESP reported 33/50 Program releases of 50,300 pounds. This is a 41 percent reduction compared to the goal of reducing releases of the program specific chemicals by 50 percent by 1995. If all TRI releases are considered instead of only the specific chemicals in the 33/50 Program, GESP has achieved an overall 54 percent reduction using 1988 as the baseline.

GESP uses a single facility-wide production ratio in its annual TRI reports. The ratio is based on annual manhours in the operations area for direct charge hourly employees. This is a reasonable method of computing a production ratio for a research facility where production is limited to development and testing requirements, and most of the releases occur in the shop areas. For 1992, GESP reported a production ratio of 0.90. Applying this ratio to GESP's 1992 TRI releases produces an adjusted total release figure of 55,330 pounds. Based on the 1992 adjusted releases, GESP achieved a 17 percent reduction in TRI releases between 1991 and 1992 after correcting the raw TRI data for the change in activity level at the plant.

[23]Most of GESP's TRI data is derived from material purchase records. These records indicate how much of each material was brought on site. Releases are then either calculated or estimated. For volatiles, including solvents, releases are calculated by subtracting quantities that are treated or recycled from the total quantities brought on site. The difference is assumed to be the release to the air. Releases of metals, such as chromium and nickel, result from chemical milling operations. Releases are estimated based on laboratory reports on discharge samples taken at the industrial waste treatment plant.

E.6.2.4 Implementation and Results

E.6.2.4.1 F119 Program Results

The F119 design incorporates two important environmental innovations in the fuel system, but neither innovation was initially undertaken for the environmental benefits. Instead, the innovations were driven by operational requirements. The first innovation involves the augmentor fuel dump. On military engines, the augmentor is used to add fuel to the hot engine exhaust stream to boost power. Under some conditions, augmentor fuel dumps are visible in the sky, a undesirable operational characteristic that the Air Force wanted to minimize. The fuel dump was eliminated by redesigning the fuel spray bars. The second fuel system innovation involves engine shut down. On the F100 and other engines, fuel is dumped at engine shut down. The fuel is drained onto the ground to empty the fuel manifolds, preventing the hot fuel from forming carbon deposits. On the F119, the need for a fuel dump at shut down was also designed out.

Since the F119 has completed its critical design review, the engine's basic configuration and materials have been reviewed and accepted. Changing these parameters now becomes increasingly difficult due the large cost and schedule impacts that redesigns usually cause. Given this fact, most of P&W's pollution prevention efforts are now focused on logistics support.

Design of the logistic support system for the F119 is being carried out using the logistics support analysis (LSA) process. The LSA process is defined in military standard 1388, Logistics Support Analysis (MIL-STD-1388). LSA requirements for the F119 include a tailored subset of the MIL-STD-1388 steps that were included in the standard at the time the contract was awarded including the use of electronic storage for all LSA data. This should make the tasks of identifying and managing the hazardous materials needed to support the F119 much easier compared to older systems, but this goal may not be

realized due to "holes" that remain in the management of hazardous materials data. This issue is address later in the case study.

Data on hazardous materials that are needed in maintenance and repair procedures for the engine are generated by maintenance and repair engineers. The engineers define each maintenance and repair task in detail and load the data into the LSA. The data on each task includes the procedural steps, tools, materials, manhours, number of works, training requirements, skill levels, etc. need to complete each task.

Along with the usual data on the quantity of material required, the unit of issue, the supply system identification numbers, etc., hazardous materials must each be identified in categories that are useful for environmental management. For example, useful information includes the composition of mixtures, data on the types of hazards present, and on the regulations that apply. Regulations include requirements for spill reporting, cleanup, recording keeping, marking, transportation, etc. For the F119, the only "environmental" data elements in the LSA data base include a general indicator that a material is hazardous. Even with this limitation, a data base that associates hazardous materials with specific tasks and processes has the potential to vastly improve current management capabilities.

In writing maintenance procedures for the F119, maintenance engineers are required to specify approved procedures. This means using the service process operation procedures (SPOPs) where one is available. The SPOPs are contained in a joint service technical manual. This does not prevent a P&W maintenance engineer from proposing a greener material as a substitute, but the burden for proving to management and the military that the substitute is both safe and effective will fall to the engineer. Getting the data needed establish the facts to justify a substitute requires both time and money for testing. Neither is budgeted within the program. The result is that SPOPs are being specified even where the engineers believe that safer materials and processes are available. SPOP 3 is an example.

SPOP 3, Vapor Degreasing, requires the use of either tetrachlorethylene or 1,1,1-trichloroethane.[24] These are the only authorized solvents in the technical order for vapor degreasing of P&W engine parts within the military.

Another issue in the F119 LSA data base concerns how data on standard procedures should be entered. Until the middle of 1993, P&W engineers entered complete material data (quantity, unit of measure, item name, etc.) for each material needed within each step of a maintenance task. After receiving direction from the Air Force that data for standard procedures was not needed to write F119 technical orders, the information on materials needed to carry out the standard procedures was deleted. The Air Force's direction to P&W failed to consider that the LSA data was useful for more than simply writing F119 technical orders. Since a large portion of all maintenance tasks involve using standard procedures, the usefulness of the LSA data base for managing hazardous materials has been greatly reduced.

E.6.2.4.2 Environmental Metrics

GESP uses a variety of environmental metrics for managing its environmental programs and measuring progress. The metrics fall into two categories: those required by P&W policy and those selected and defined locally.

P&W's pollution prevention policy requires each facility to track process hazardous waste generated, toxic air emissions, and the three largest volume waste streams. The first two of these quantities are also used to track progress toward the UTC and P&W reduction goals. In addition, P&W's volatile halogenated chemical policy requires tracking of all volatile halogenated chemicals. Finally, UTC uses TRI data to track the corporation's progress against the 33/50 Program's goals.

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[24]U.S. Air Force, T.O. 2-1-111, Technical Manual, Standard Maintenance Procedures, "Navy, USAF and Army P&W Aircraft Engines," Change 1, (Philadelphia, PA: Naval Air Technical Services Facility, 15 September 1992) 3-10.

At the facility level, GESP tracks each waste stream that contributes to one of the UTC or P&W goals. Hazardous waste is tracked by waste stream using the hazardous waste manifest. Toxic air emissions and halogenated chemicals are tracked using TRI data. Since TRI data is only prepared annually, the more frequent internal reports are prepared using the TRI methodology.

The information is stored in a data base maintained by the environmental staff. The data is regularly sorted by department and each senior manager working for the GESP Vice-President receives a report listing the department's waste generation and progress toward meeting GESP reduction targets.

GESP also tracks non-hazardous solid waste disposal and recycling activity and reports the data monthly to Palm Beach County. Recycling includes paper, cardboard, aluminum, wood, tires, batteries, and concrete.

GESP also sells other scrap metals for recycling, but the efforts are reported on the facility's TRI reports. For example, in 1992, GESP reported recycling 79,000 pounds of chromium containing alloys and 170,000 pounds of nickel alloys. In 1991, GESP recycled 32,000 pound of cobalt alloys, but in 1992, the quantity fell below the reporting threshold. The recycling quantities for scrap metals are calculated from the recycling weight receipts. Each receipt is itemized by P&W specification number. Knowing the P&W specification number allows the environmental staff to determine the characteristics of each alloy and to determine the percentage of each reportable metal in the scrap. The percentage is then multiplied by the weight of the alloy to determine the amount of each reportable material.

E.6.2.4.3 Management of Pollution Prevention Objectives

P&W's management of pollution prevention initiatives and objectives has not been a well coordinated effort across programs, functional areas, and plants; however, this is changing. P&W recognizes the need to develop and implement a unified approach to pollution prevention and all of its environmental management efforts. To achieve a more

unified approach, the P&W Environment, Health, and Safety unit is developing new policy statements and guidance, preparing an integrated pollution plan, and expanding and coordinating the efforts of three interdepartmental working teams. Each team is tasked to coordinate efforts on specific initiatives and to implement specific actions. The teams are comprised of members different plants and functional areas.

The Environmental Design Team is working on incorporating pollution prevention into the design norms developed by the Charter Parts Council, developing procedures for use by Design Metallurgy to review designs, and changing material specifications. The Environmental Technology Team is identifying P&W and customer environmental needs that are associated with materials and processes, developing technical programs to address the needs, and matching programs with potential funding sources. The third team, the Waste Elimination Steering Committee is working on facility-level waste minimization programs, baselining waste stream data, and coordinating actions to minimize duplication of effort and to ensure the transfer of minimization information between parts of the company.

E.6.2.4.4 <u>Pollution Prevention and the National Environmental Policy Act (NEPA)</u>

The noise made by military aircraft is extensively studied and documented in Air Force NEPA documents. To support this process, P&W's F-119 contract, as well as it other engine contracts, calls for the company to provide several types of noise measurements. This data is then used for a variety of noise studies and in computer models for mapping expected noise contours at military installations. This information routinely used in environmental impact analysis.

Pollution prevention issues other than noise have not been studied in past Air Force NEPA documents. This is a procedural issue that the Air Force should correct.

E.6.3 Implementation Contextual Factors

The seven factors discussed in this section are commonly cited in the implementation literature as being important for understanding an implementation process. Observations concerning the impact of each factor on the pollution prevention implementation efforts at LASC are presented below. The observations are relative to LASC's implementation of its internal pollution prevention policies as well as government requirements.

E.6.3.1 Organizational Structure and Relationships

P&W's approach to implementing pollution prevention in the F119 program is centered in its implementation of integrating product development

Figure E.2 shows the program's overall management structure and includes both the line and staff functions. Note that P&W functional managers support the program, but are not directly responsible for the program.

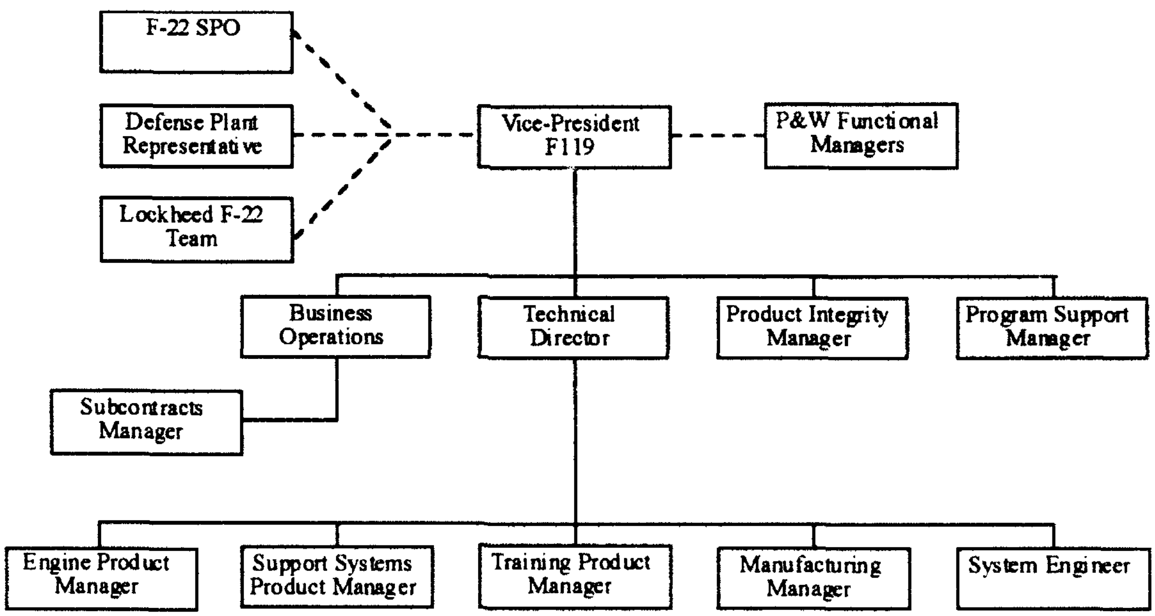

Figure E.2. F119 Program Organization

Figure E.3 shows the F119 integrated product development team structure. This product oriented structure is being using to implement P&W's integrated product development process.

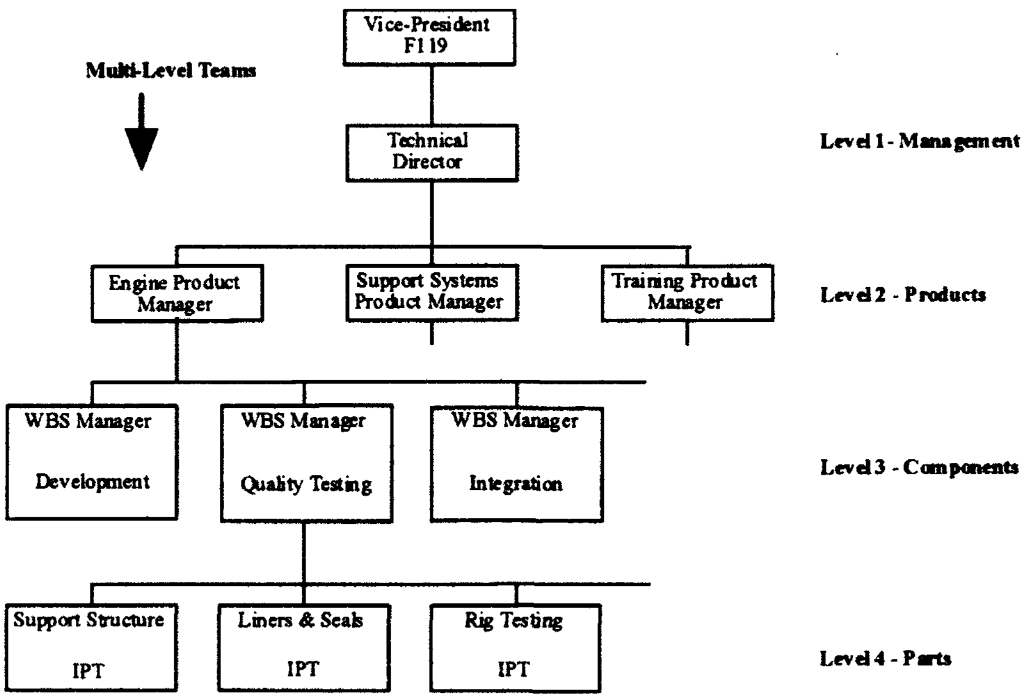

Figure E.3. Integrated Product Development Structure

The IPT structure is organized around the three product managers: engine, support systems, and training. Below the product level there are component level teams. At the component level, team managers are responsible for a major portion of the product as defined in the program's work breakdown structure (WBS). These managers have the primary responsibility for controlling costs and meeting technical requirements and milestones.

Individual IPTs are at the lowest level of the structure and they have responsibility for one or more parts of a product. Since design decisions are made in the integrated product teams (IPTs), the success of this approach rests with having knowledgeable people on the IPTs with expertise in all the functional area needed for the team to make

balanced design decisions. In a traditional development, the management process and structure would follow functional lines such as structures, electrical, mechanical, manufacturing, materials, etc., instead of being organized around the products and their logical components and parts.

Individual IPTs are usually headed by a design engineer. In addition to engineering, team members usually include customer support; the producer, either manufacturing or the external supplier; finance; and the customer. Other functional representatives are included as appropriate.

Within the IPT structure, primary responsibility for providing technical expertise on pollution prevention is assigned to the IPT's materials engineer. IPT members from other functions are responsible for pollution prevention within their areas of expertise. For example, the manufacturing engineer would be concerned with process selection and design, the logistics representative would be concerned about maintenance and repair materials and processes, etc.

Outside the IPT structure, various functional managers also have pollution prevention responsibilities. The relationships between some of the IPT and some of functional responsibilities are illustrated in Figure E.4.[25] The role of the environmental staff, shown in the figure under facilities, includes technical expertise, interfacing with regulatory agencies, and providing information on environmental regulations to the IPTs.

E.6.3.2 Goal Structure

Within the F119 program, there are no specific quantitative environmental goals. This is in marked contrast to most other support areas. For example, the prime item development (PID) specification for the F119 contains numerous quantitative reliability

[25]Pratt & Whitney, "Hazardous Materials Program Plan," F119-PW-100, Engineering and Manufacturing Development Program, (Wright-Patterson AFB, OH: Aeronautical Systems Division. 6 March 1992) 28.

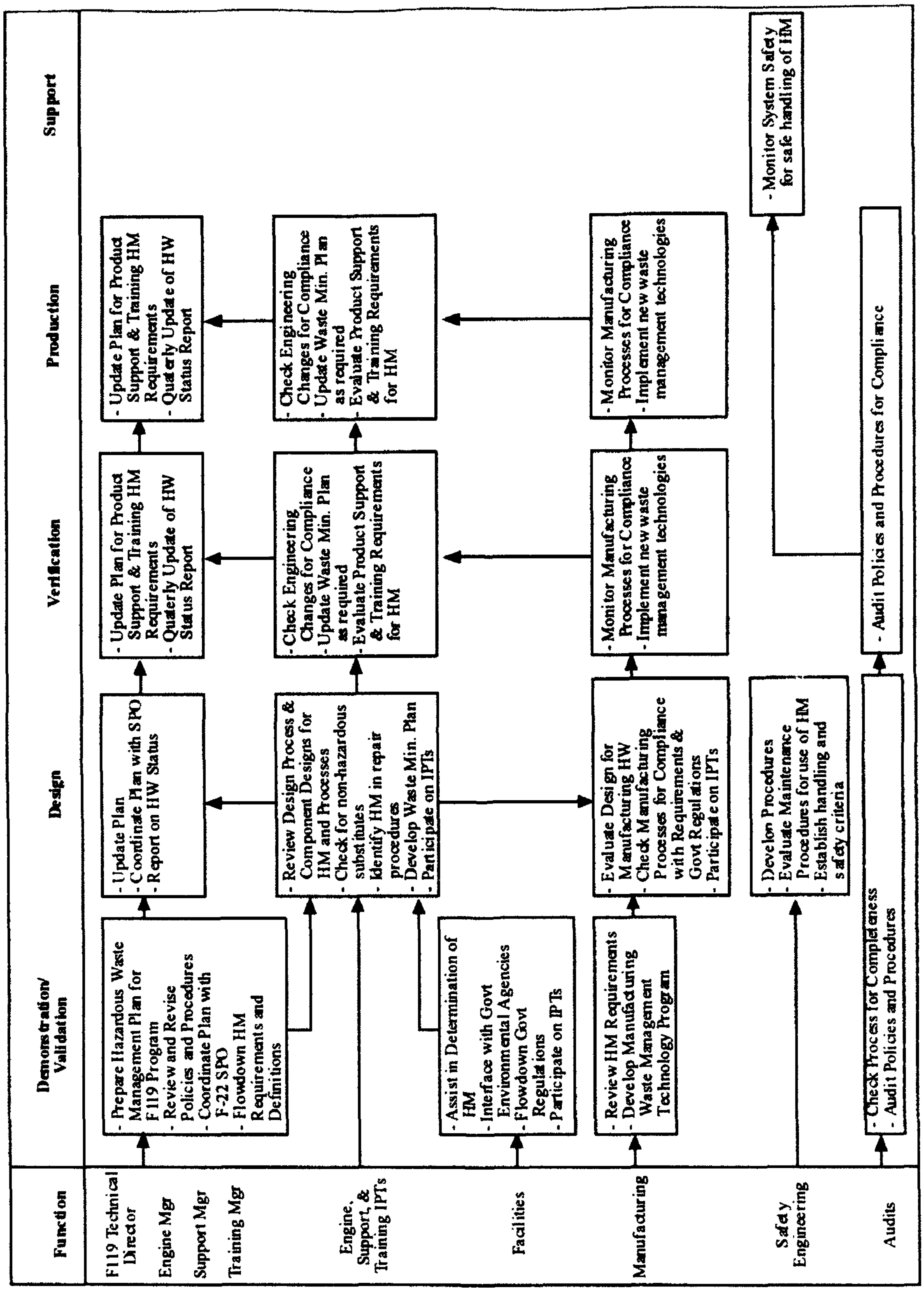

Figure E.4. Hazardous Materials Program Process

and maintainability requirements and goals in section 3.4. In addition to the quantitative requirements, section 3.4.2.2 of the PID specification contains twenty-four non-quantitative maintenance requirements for the engine system. These requirements are essentially a list of design preferences and include items such as torque wrenches shall not be required for organization level maintenance tasks and the color red shall not be sued on the engine for any identification means.

In addition to the requirements listed in the PID specification, P&W has identified additional supportability criteria as a part of Logistic Support Analysis (LSA), Task 205, Supportability and Supportability Related Design Factors.[26] The LSA is a contract requirement. The criteria P&W identified include items such as reducing total peculiar organizational support equipment quantity, weight, volume, and price (1985 dollars) by 60 percent, 65 percent, 60 percent, and 40 percent, respectively from the F100-PW-100 1983 support equipment list values; providing organizational support equipment that is usable by one person; and designing the engine so there are no scheduled oil changes, conical type gaskets are not used, the engine gas path is tolerant of damage from foreign objects, and engine to airframe disconnects are easily accessible.

Thus, the supportability requirements for the F119 include both quantitative and qualitative items for the design team to meet. By comparison, the hazardous materials program specification required the preparation of a management plan and a listing of hazardous materials. At no point in the program were specific environmental criteria ever developed by the Air Force or was P&W required to develop criteria.

Despite the lack of a specific effort to develop environmental goals, environmental criteria have been identified in some areas of the program. For Example, in P&W's corrosion control efforts, the engineers responsible for titanium alloys have specifically

[26]Pratt & Whitney, "Advanced Tactical Fighter Engine, F119-PW-100, Logistic Support Analysis, Task 205, Supportability and Supportability Related Design Factors," (Wright-Patterson AFB, OH: Aeronautical Systems Division, December 1992) 1-12.

excluded processes that use Occupational Safety and Health Administration (OSHA) restricted compounds, methyl alcohol, and halogen-containing compounds.[27] Additionally, anti-gallant compounds for fasteners containing graphite or lead are excluded and cadmium and nickel-cadmium fasteners are not to be used.

E.6.3.3 Knowledge Base

P&W is a member of the Aerospace Industries Association (AIA) Turbine Engine Testing Working Group. The group is made up of government and industry organizations routinely involved in aircraft turbine testing. The group's purpose is to share information on all aspects of engine testing. Recent meetings have been largely devoted to environmental issues associated with engine testing and operation. For example, emissions of nitrogen oxides (NO_X) from engine test cells and replacement of halogenated engine cleaning solvents have been key topics.

Title II, Section 233 of the Clean Air Act Amendments of 1990 requires EPA to study NO_X emissions from aircraft engine test cells to determine if controls of emissions are feasible and appropriate. The AIA Aircraft Engine Test Cell Task Force was formed as a part of the working group to address the issue for the engine testing community and to help steer the study. In addition to P&W, the task force has members from General Electric Aircraft Engines, Allison Gas Turbine, Garrett Engine (Allied-Signal), Textron Lycoming, Williams International, The Boeing Company, Dunaway & Cross, the Department of Defense (DoD), the Navy, the Air Force, and the National Aeronautics and Space Administration (NASA). The group has studied three potential control technologies and concluded that none of the available technologies are acceptable considering both cost and impacts on data collection during the testing.

[27]Pratt & Whitney, "Advanced Tactical Fighter Engine, F119-PW-100, Propulsion and Power System Integrity Program (PPSIP) Master Plan," Volume I, Mechanical/Electrical Systems Integrity (Wright-Patterson AFB, OH: Aeronautical Systems Center, 1 February 1992) 5.1-132 to 5.1-162.

E.6.3.4 Resources

A lack of government funding to qualify "greener" materials and processes for use in standard procedures is causing new technical data to be written that calls for the use of chemicals the Air Force is working to eliminate. The standard procedures are used to maintain and repair all P&W engines in all the services; however, none of the individual programs wants to pay for qualifying new materials and processes that benefit all engines. The Air Force's guidance on replacing P-D-680 is a good example.

The materials engineering organization at San Antonio Air Logistics Center (SA-ALC) advised P&W to,

> . . .consider the use of MIL-C-87937. This is a specification for a biodegradable, water based cleaner. This is NOT a drop in replacement for P-D-680, which is a petroleum based dry cleaning solvent. The use of MIL-C-87937 requires totally different procedures. Because it is an aqueous cleaner, it requires rinsing and drying steps after cleaning. In addition, aqueous cleaners cannot be used on certain metals which are high susceptible to flash rusting. . .
>
> . . . The disposal of P-D-680 is environmentally difficult. In many instances, the P-D-680 must be either burned or be disposed of as waste oil. This can incur significant costs to the AF. MIL-C-87937 contains biodegradability requirements. In many instances, the local municipal treatment plant can biodegrade the MIL-C-87937 cleaners. This allows the AF to incur significant savings. . .
>
> The replacement of P-D-680 Types I, II, and III with MIL-C-87937 require that the responsible engineer (AF and contractor) conduct a feasibility study because of the different chemical and procedural changes required. . .[28]

The letter does not provide the results of any government conducted materials testing nor does it identify a source of funding for conducting the needed tests or for funding the staff hours needed to write the technical reports that must be submitted to the government's material engineers for approval. In addition, none of P&W's existing contracts provide funding for this type of activity.

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[28]Captain Peter Poon, letter to SA-ALC/TILTR, "Alternatives or Replacement for P-D-680." (Kelly AFB, TX: SA-ALC/TIESM, 7 April 1993).

E.6.3.5 Dispositions

The overall disposition of GESP employees on environmental issues was observed during each interview and was evaluated using a questionnaire during the site visit. Results of the questionnaire are presented in detail in Appendix F. A summary of the survey results is presented below.

The questionnaire consisted of a total of 27 questions and contained questions on six general topics: environmental behavior, environmentalism, environmental concerns, pollution prevention, and environmental performance. Twenty of the 27 questions were taken from national surveys on the environment.

At GESP, the employees answered eight of twenty questions differently than people in a national random sample. In this study, finding five or more different answers from the national data is assumed to be an indication that employees have a different disposition toward the environment than the national average. Note that there are no "right" or "wrong" answers to the questions and that different is relative to the question asked--different behaviors, different concerns, etc.

As a result of evaluating the survey data[29] and the information gathered during the interviews some general conclusions can be drawn. First, the employees tend to believe that the condition of the environment is getting better. Therefore, they are less worried about the environment than people nationally. They also believe that, in general, business, industry, and the Government all spend too much time worrying about the environment, but that their company is not enough worried.

[29]Note that there are three sources of potential bias with the survey results. First, the data collected at P&W does not represent a random sample. Second, the questionnaires were distributed in the work place while the national data are from telephone surveys. This biases the definition of "environment," since environment is not defined (it may mean the local environment, national environmental, global environment, etc.). On the questionnaire, respondents appear to assume that several questions are referring to the work place environment. This would not occur in the telephone survey. Finally, there is a bias toward professional and management employees among the respondents. At P&W, 91 percent of the respondents identified themselves as managers, engineers, or other professionals.

They believe that environmental regulations can go too far, but they are willing to see jobs lost because of environmental regulations and they are willing to pay higher taxes to protect the environment. They contribute to environmental groups and they are more likely to voluntarily participate in recycling programs. Finally, almost 70 percent believe that the company strongly supports efforts to prevent pollution and that more time should be spent on environmental issues.

Summarizing the survey data, the employees at GESP display different views than those found in the national surveys. They have a more positive outlook on the condition of the environment and are less worried, but they are just as likely to consider themselves environmentalists.

In conclusion, the results of the survey and interviews indicate that, in general, the employees at GESP: 1) understand the policy, 2) support pollution prevention or are neutral toward it, and 3) do not have a strong negative disposition toward pollution prevention activities.

E.6.3.6 Decision Making and Management Procedures

While development work on the F119 occurs in the IPTs, most of the pollution prevention activities at GESP have taken place in task groups formed to look at specific environmental issues such as reducing emissions from hand wipe clean operations or from vapor degreasers. Prior to 1993, most of the task group activity occurred at individual P&W plants. Over the past year, P&W company-level groups have been organized to deal with individual issues.

The task group working on elimination of vapor degreasers is a good example of a P&W company-wide group. The group is multi-disciplinary and includes people from headquarters as well as from individual facilities. The group's main concerns involve solving common problems such as developing performance criteria; performing material compatibility laboratory tests; performing shop tests for smell, cycle times, quality

impacts, etc.; developing new and revised specifications; and working with outside vendors.

In considering replacement chemicals and processes to vapor degreasing, the work group established three primary environmental criteria: 1) replacements should have zero potential for depleting stratospheric ozone, 2) materials should contain no chemicals from the EPA 33/50 Program list, and 3) the material's health and safety characteristics be acceptable, especially its flammability. In addition, the group addressed specific environmental issues associated with individual alternatives such as the aquatic toxicity of potential releases from aqueous cleaning processes and the characteristics of toxic residues on filters.

After gathering the needed technical information, the group developed a new P&W specification (PWA 36603) on aqueous cleaning. In developing the specification, the group examined a wide range of alternatives to the halogenated cleaners and the highly volatile organic cleaners that were being used. As a results of the group's investigation, a number of classes of materials were identified as potential replacements. Alternatives included hot inhibited alkaline cleaning solutions, detergents, water soluble citrus based terpenes, alcohols, and a number of proprietary cleaners. Adoption of the specification is ultimately the responsibility of each business unit. Because of corrosion, bonding, soldering, and other concerns, not all materials can be cleaned using any one of the potential replacements.

Adopting a new process to replace a vapor degreasing operation involves reviewing the manufacturing process operation procedure (POP) that calls for using vapor degreasing and determining if PWA 36603 or another process can be used as a substitute. The business unit's decision making is aided by the technical data on material compatibility, impacts on cycle time, etc., assembled by the P&W task group. The progress of each business unit in eliminating the use of vapor degreasers is tracked at P&W using the total number of vapor degreasers at each facility as the metric.

At GESP, a local working group is responsible for investigating individual vapor degreasing operations. Through the group's efforts, several degreasers were eliminated and the work transferred to other degreasers. This action reduced number of degreasers and reduced total emissions by reducing the total surface area of solvent subject to volatile losses. The operating hours of one degreaser were reduced from 24 hours per day to 8 hours per day. Emissions were reduced allowing the degreaser to cool down when not in service. Lowering the temperature of the degreaser reduced volatile losses. Another vapor degreaser was eliminated by substituting aqueous cleaning for vapor degreasing in tube bending operations. The operation uses bending fluids and light oils to pressurizing the tubes during bending to reduce crimping. Following bending, the residues must be removed. Usage of the remaining vapor degreasers was further reduced by cleaning all gas turbine parts in an alkaline cleaning solution. Finally, a small distillation unit has been installed to purify the solvent from one of the remaining vapor degreasers.

In spite of the substantial reduction in the number of vapor degreasers and in total emissions from vapor degreasers, important barriers remain to implementing pollution prevention on a wider scale. Funding for testing new materials is scarce and has been virtually unavailable for pollution prevention initiatives beyond vapor degreasing and hand wiping operations. In addition, the large work force reductions have reduced the number of people available to work on the work groups. The result, has been a lot of internal issue papers, but little in the way of additional resources.

E.6.3.7 Communications

The single biggest improvement in communications that impacts pollution prevention probably involves relationships with suppliers. On the F119, P&W was required to report on the hazardous materials used in components purchased from outside suppliers. This helped encourage IPT members and subcontract managers to begin

discussing environmental issues and to start becoming familiar with a supplier's hazardous materials and the resulting waste streams.

In addition to improving communications with its suppliers, improving the flow of information with its customers has been a major goal at P&W the last several years. In early 1993, Bear, Stearns & Company conducted a survey of P&W customers as part of their investment research on United Technologies. They found that,

> . . .Pratt's leading customers sensed a dramatic improvement in Pratt's customer service. Most emphasized Pratt had historically maintained a very arrogant and haughty attitude, one in which the manufacturer expected the customer to come to Pratt to do business. Unanimously, they noted material improvement in the company's customer service effort, a faster turnaround time between order and delivery, and, on balance, they indicated that Pratt seemed to be much hungrier, more creative, and more aggressive in pursuing new business opportunities. In fact, on six different occasions, customers suggested that the new Pratt & Whitney was much more customer-oriented and no longer had an arrogant attitude.[30]

The report also suggests that the improvement began, "within the past twelve months." This timing correlates well with the mid-1992 timing of the dramatic changes in P&W's environmental management efforts and suggests that senior management is successfully changing the organizational culture.

The "Repair Team" at GESP provides an example of management working to improve internal communications. The Repair Team involves four organizations from three functional areas as shown in Figure E.5. Repair Technology develops repair processes and materials. Repair Engineering develops repair procedures and specifies logistical support. Repair Support Equipment is responsible for the equipment needed to support an engine and Technical Publications is responsible for technical manuals and other technical documentation.

[30] S. Binder, "United Technologies Company Report," (New York, NY: Bear, Stearns & Company, 11 May 1993) 11.

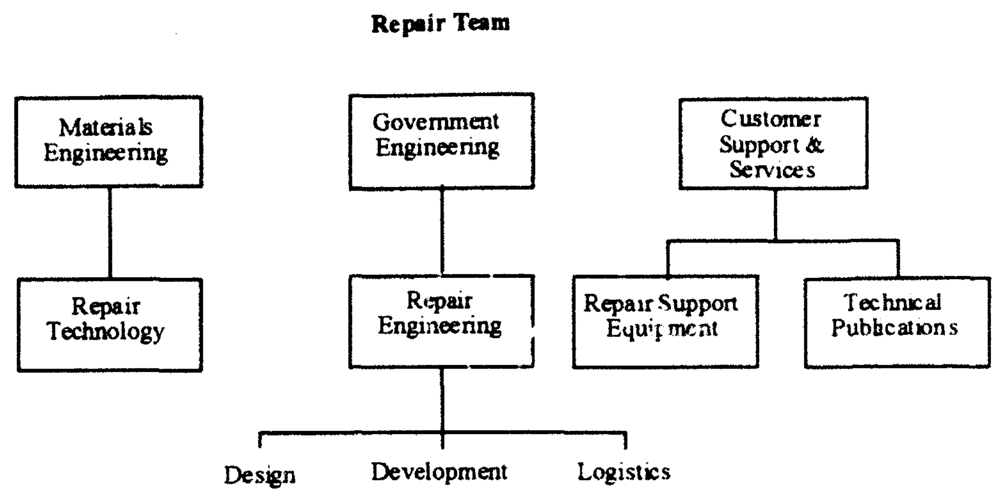

Figure E.5. Pratt & Whitney, Government Engines and Space Propulsion, Repair Team

Developing environmentally friendly repair procedures is a new task the Repair Team has undertaken. One of the goals of the effort is to provide pollution prevention information in a form usable by repair engineers. Providing the engineers a listing of acceptable and unacceptable chemicals did not prove to be an effective means of changing traditional chemical uses. Repair engineers do not "think" about repair tasks in chemical terms. They design complex repair tasks by specifying sequences of basic standard procedures. To address a chemical or process, one must change the standard procedures that call for the use of the chemical or process. Thus, telling the repair engineer to use MIL-C-87937 instead of P-D-680 is not effective. Instead, one must change the standard procedures that requires the use of P-D-680. Until this is done, MIL-C-97937 cannot be specified in repair tasks.

To help solve this problem, the repair team at GESP identified all of the standard procedures that call for one or more of the chemicals identified on the two lists the Air Force has provided. One list was provided by the system program office and includes the EPA 33/50 Program chemicals and several others. Another list was provided by provided

by the Air Force engine repair depot at Kelly AFB, TX and includes chemicals regulated by the Texas Clean Air Act.

Using a combined listing, the team researched all of the primary and secondary references to the chemicals in the standard procedures. Primary references are standard procedures that call for one of the chemicals. Secondary references occur when one standard procedure calls for the use of another standard procedure and the referenced procedure requires the use of one of the chemicals.

Using a matrix that the team developed, a repair engineer is now able to select acceptable standard procedures where they are available. Getting the funding and labor hours needed to change the outdated standard procedures continues to be a problem.

E.7 Annex to Appendix E -- Text of Contract Pollution Prevention Requirements

Paragraph 6.1.12 of the F119 Statement of Work, Contract F33657-91-C-0007, defines the hazardous materials program requirements.

> 6.1.12 **Hazardous Materials Program.** (WBS 61D0) The contractor shall develop, maintain, update, and implement a hazardous materials program. The program shall focus on the elimination of hazardous materials where possible or mitigation of consequences as appropriate. The tasks shall address the entire life cycle of the engine to ensure optimization and balance between design parameters and hazardous material constraints. The program shall comply with the regulatory requirements contained in the IMP Narrative 6.1.12 to include transportation, storage, use, and disposal of hazardous materials, the disposal of hazardous waste, and reporting to the Government. The contractor shall develop and maintain a list of all hazardous materials (including amounts and exposure limits) used and produced during this program. The hazardous materials program shall be defined in a Hazardous Materials Program Plan. (OT-90-34207, OT-90-34209).
>
> The contractor shall report on engine noise, smoke, and exhaust gas content (OT-90-34227).

The work breakdown structure (WBS) code, listed at the beginning of the paragraph, identifies the tasking in the program management system. The integrated master plan (IMP) narrative is a contractor prepared document that is used to define and track program requirements. The codes listed at the end of each paragraph, such as

OT-90-34207, are data item descriptions (DIDs) that provide information to the contractor on how the information required by the SOW is to be provided to Government. Definitions for the DIDs are individually specified in another portion of the contract using one or more copies of Department of Defense Form 1423-1. For example, OT-90-34207, provides information on the Hazardous Materials Program Plan. The form specifies the time allowed for the contractor to develop the plan and for the Government to review the contractor's submittal. In addition, the DID defines the plan's format, the number of copies to be submitted, and identifies the offices to receive a copy.

APPENDIX F

ENVIRONMENTAL SURVEY

F.1 Purpose

The purpose of the survey is to provide an indication, during the site visits, on whether defense contractor employees that implement Department of Defense, Air Force, and company pollution prevention policies have significant negative predispositions toward these policies.

Based on prior visits to Lockheed Aeronautical Systems Company, The Boeing Company, and Texas Instruments and on work with the Electronic Industries Association, worker predisposition toward the environment did not appear to be a problem in the aerospace or electronic industries. Thus, the research hypothesis is that attitudes toward the environment are the same for defense industry workers and the United States population. The alternative is that attitudes among defense workers on environmental issues are different than the U.S. population.

H_0: Environmental attitudes in defense workers = Environmental attitudes in the population

H_a: Environmental attitudes in defense workers ≠ Environmental attitudes in the population

If the hypothesis is supported, predisposition will not be further explored. If the surveys fail to confirm the hypothesis, dispositions will be discussed during the interviews.

F.2 Background

In earlier research on policy implementation, the predisposition of the implementators has been identified as a key factor in whether a policy will succeed or fail. Edwards believes that predisposition is important since,

> Many policies fall within a 'zone of indifference.' These policies will probably be implemented faithfully because implementors do not have strong feelings about them. Other policies, however, will be in direct conflict with the policy views or personal or organizational interests of implementators. When people are asked to execute orders with which they do not agree, inevitable slippage occurs between policy decisions and performance.[1]

Van Meter and Van Horn suggest that three elements of disposition are important. They state:

> . . . Three elements of the implementors' response may affect their ability and willingness to carry out the policy: their cognition (comprehension, understanding) of the policy, the direction of their response toward it (acceptance, neutrality, rejection), and the intensity of that response.[2]

The first element, cognition, will be evaluated during the interview process. The second element, the direction of disposition is the primary area of interest in the survey. The research hypothesis is that disposition is not a problem--that the implementator's accept the policy or are neutral toward it. The survey will also provide some information on the third element, intensity of disposition. This area will be further evaluated in the interviews if negative predispositions are found. In addition, the interviews will explore the reasons for negative predispositions if the survey indicates that negative predispostions are an issue in implementing pollution prevention policies.

F.3 Question Selection

Van Meter and Van Horn suggest that implementators may fail to execute policies faithfully because they reject the goals contained in them. Rejection of a policy's goals can occur for a variety of reasons: they may offend implementator's personal value systems, extraorganizational loyalties, sense of self-interest, or existing and preferred relationships.

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[1]George C. Edwards III, Implementing Public Policy, (Washington D.C.: Congressional Quarterly Press, 1980), 90.

[2]Donald S. Van Meter and Carl E. Van Horn, "The Policy Implementation Process: A Conceptual Framework," Administration & Society, 6, no. 4 (February 1975): 472.

Van Meter and Van Horn also believe that, at minimum, it would seem that shared attitudes make implementation easier.

Data on general environmental attitudes is widely available. On the other hand, no attitudinal data on pollution prevention that would be useful here, was identified in the literature. Based on these facts, a questionnaire was constructed using a number of general questions on environmental issues where national data was available. These questions were used to determine if the subjects in this study have significantly different opinions and attitudes on current environmental issues that the US population as a whole. In addition to the general questions, a number of new questions specific to pollution prevention implementation were used.

The questions cover three categories of responses: attitudes--what people say they want, beliefs--what people think is true, and behavior--what people do. In addition, the questions are categorized according five general environmental areas:

1. Environmentalism,
2. Environmental behavior,
3. Environmental concern,
4. Environmental performance,
5. Pollution prevention.

F.4 Questionnaire Questions

Questions and data for the first four areas were all taken from national polls conducted in conjunction with the 20th Earth Day in April 1990. The national polls were conducted by the New York Times/CBS News[3] (CBS), Gallup[4] (GAL), and USA Today[5] (USA).

[3]CBS News, "Earth Day +20," New York Times/CBS News Poll, (New York: CBS News, 16 April 1990).

[4]George Gallup Jr. and Frank Newport, "Americans Strongly in Tune with the Purpose of Earth Day 1990," Gallup Report, no. 295 (April 1990): 5-14.

[5]Gordon S. Black Corporation, Environmental Survey, (Arlington, VA: USA Today, 9 July 1990), Study Number 3206.

F.4.1 Environmentalism

1. Do you consider yourself to be an environmentalist or not? (GAL: yes 73%, no 24%, no opinion 3% of 1223 adults). If yes, do you consider yourself a strong environmentalist? (GAL: strong environmentalist 35%, not strong 38%) -- Question 4

2. Do you agree or disagree with the following statement: Protecting the environment is so important that requirements and standards cannot be too high and continuing environmental improvements must be made regardless of cost. (CBS - Q33: agree 74%, disagree 21%, DK/NA 2% of 1515 adults) -- Question 16

3. Think about the people who are actively involved in groups that are concerned about environmental issues. Do you think these people are reasonable people, or are most of them extremists? (CBS - Q39: reasonable 60%, extremists 27%, depends (vol) 6%, DK/NA 7% of 1515 adults) -- Question 15

4. Do you agree or disagree with the following statement: We must protect the environment even if it means increased government spending and higher taxes. (CBS - Q33: agree 74%, 21% disagree, DK/NA 5% of 1515 adults) -- Question 17

5. Do you agree or disagree with the following statement: We must protect the environment even if it means jobs in your community are lost because of it. (CBS - Q46: agree 56%, disagree 36%, DK/NA 8% of 1515 adults) -- Question 18

6. There is not much one person can do to help the environment. Do you strongly agree, somewhat agree, somewhat disagree, strongly disagree? (USA - Q24B: strongly agree 13.9%, somewhat agree 20.5%, somewhat disagree 26.6%, strongly disagree 36.6%, refused 1.8%, DK .7% of 850 adults) -- Question 14.

F.4.2 Environmental Behavior

1. How often do you have conversations with other people about the environment? Once a day, once a week, once a month, less than once a month, never. (USA - Q27: once a day 11.4%, once a week 39.5%, once a month 28.0%, less than once a month 11.1%, never 9.8%, DK .2% of 850 adults) -- Question 3.

Which of the following things, if any, have you or other household members done in recent years to try to improve the quality of the environment?

2. Boycotted a company's products because of its record on the environment. (GAL: yes 28%, no or DK 72% of 1223 adults) -- Question 21.

3. Specifically avoided buying a product because it was not recyclable. (GAL: yes 49%, no or DK 58% of 1223 adults) -- Question 22.

4. Voluntarily recycled newspapers, glass, aluminum, motor oil, or other items. (GAL: yes 85%, no or DK 15% of 1223 adults) -- Question 23.

5. Did volunteer work for an environmental, conservation, or wildlife preservation group? (GAL: yes 18%, no or DK 82% of 1223 adults) -- Question 24.

6. Contributed to an environmental group, such as the Sierra Club, Greenpeace, the National Audubon Society, or others like these. (USA - Q28: yes 40.0%, no 58.9%, DK 1.1%) -- Question 25.

F.4.3 Environmental Concern

1. In your opinion, is the condition of the environment getting better, getting worse, or is it staying about the same? (USA - Q1: worse 64.7%, same 25.9%, better 6.8%, DK 2.6%) -- Question 1.

2. Overall, how worried are you about the condition of the environment? Are you: very worried, somewhat worried, not very worried, *not at all worried*? (USA - Q3: not at all worried 6.4%, not very worried 10.0%, somewhat worried 48.7%, very worried 34.4%, refused .1%, DK .5% of 850 adults) -- Question 2.

3. Do you think the government today is too worried about the environment, not worried enough, or expresses about the right amount or concern about the environment. (GAL: not worried enough 75%, just right 18%, too worried 3%, DK 4% 0f 1223 adults) -- Question 5.

4. Do you think business and industry today is too worried about the environment, not worried enough, or expresses about the right amount or concern about the environment. (GAL: not worried enough 85%, just right 11%, too worried 1%, DK 3% of 1223 adults) -- Question 6.

5. Do you think your company is too worried about the environment, not worried enough, or expresses about the right amount or concern about the environment. Question 7.

F.4.4 Environmental Performance

1. When it comes to keeping the environment clean, how would you rate the federal government? Would you say they are excellent, good, fair, poor? (USA - Q17: excellent 0.6%, good 11.9%, fair 47.9%, poor 36.5%, refused .1%, DK 3.1% of 850 adults) -- Question 8.

2. In general, how would you rate U.S. corporations for keeping the environment clean? Would you say they are excellent, good, fair, poor? (USA - Q16: excellent 1.1%, good 14.1%, fair 43.8%, poor 38.8%, DK 2.2% of 850 adults) -- Question 9.

3. When it comes to the environment, how would you rate yourself? Would you say you are excellent, good, fair, poor? (USA - Q20: excellent 10.9%, good 47.2%, fair 37.3%, poor 4.1%, refused .1%, DK .4% of 850 adults) -- Question 10.

F.4.5 Pollution Prevention

1. How much opportunity to you feel you have to prevent pollution in your community? Question 11.

2. How much opportunity do you feel you have to prevent pollution in your company? Question 12

3. In your company, efforts to prevent pollution are strongly supported by management? Question 13.

4. In your company, too much time is spent on environmental issues. Question 19.

5. On this project, product quality includes reducing and controlling pollution. Question 20.

F.5 Sample Size

The sample size for each of the historical surveys are shown below:

New York Times/CBS News	1,515
Gallup	1,223
USA Today	850

Since the USA Today survey had the smallest sample size of 850, this figure will be used to check the required sample size for this survey. The method for calculating

unequal sample sizes is taken from Fliess[6], where: sample size - n_1 subjects in Group 1 (historical surveys) and $n_2 = kn_1$ in Group 2 (planned surveys)

Test hypothesis H_0: $\pi_1 = \pi_2$ against alternative H_a : $(\pi_1 - \pi_2) = 0$ (two sided)

π = response proportion	$\pi_1 = 0.65$	$\pi_2 = \pm 0.10$
α = Type I error = .10	$z_\alpha = 1.645$	
β = Type II error = .75	$z_\beta = -0.674$	
k = .05 (assumed to be small to produce small samples in the contractor plants)		

$$n_1' = \frac{[z_\alpha\{(k+1)\overline{\pi}(1-\overline{\pi})\}^{.5} + z_\beta\{k\pi_1(1-\pi_1) + \pi_2(1-\pi_2)\}^{.5}]^2}{k(\pi_1 - \pi_2)^2}, \quad \overline{\pi} = (\pi_1 + k\pi_2)/(1+k)$$

Step 1, calculate $\overline{\pi}$

$$\overline{\pi} = (0.65 + (0.05)0.75)/(1+0.05) = 0.65476$$

Step 2, calculate n_1' - the trial sample size

$$n_1' = \frac{[1.645\{(.05+1)0.65476(1-0.65476)\}^{.5} + (-0.674)\{(.05).65(1-.65)+.75(1-.75)\}^{.5}]^2}{.05(.65-.75)^2}$$

$$n_1' = \frac{[1.645\{0.23735\}^{.5} + (-0.674)\{0.198875\}^{.5}]^2}{0.0005}$$

$$n_1' = 501.696 \approx 502$$

Step 3, calculate n_1

$$n_1 = \frac{n_1'}{4}[1 + \{1 + \frac{2(k+1)}{n_1' k(\pi_1 - \pi_2)}\}^{1/2}]^2$$

$$n_1 = \frac{502}{4}[1 + \{1 + \frac{2(.05+1)}{502(.05)(.65-75)}\}^{1/2}]^2 = 696.16 \approx 700$$

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[6]Joseph L. Fleiss, Statistical Methods for Rates and Proportions, 2nd ed., (New York: John Wiley, 1981), 44-46.

The required sample size for the historical data is about 700. Since the smallest historical survey had 850 respondents, the national polls are large enough to support a Mantel-Haenszel test to compare proportions. The required sample size for each subunit to be studied is approximately .05(700) = 35. Thus, a sample size of approximately 35 is needed to test for a difference of 10% between the historical polls and data from each contractor to be studied, where $\alpha = 0.1$ and $\beta = 0.75$.

F.6 Sampling

Ideally, the survey would have given to approximately 100 members at each facility. Since this was not be possible, a conservative assumption for sample size was used--the sample size will approximate the number of people interviewed. Twenty to twenty-five was the target for interviews at each plant. Since twenty-five would be too small, a sample size of thirty-five was be used as the minimum acceptable size. Each company was informed in writing requesting that at least 35 surveys be completed during the visit. The sample was a sample of convenience selected from program personnel as agreed with the contractor's program manager at each facility. Randomization was not possible. Since a random sample could not be obtained, one of the statistical test assumptions was violated. Although the sample was not random, the contractor was not able to directly select or to limit the people that participated. This helped to reduce potential bias, but at least one significant source of bias could not be eliminated. This is discussed in the results.

F.7 Data Analysis

Since the purpose of the questionnaire is to provide information prior to beginning interviews, preliminary data analysis was done in the field using SPSS on an IBM compatible computer. Statistics to calculated include frequencies and percentages for each question. Raw data was examined for percentage differences larger than ten percent from the national data. As the sample size calculation shows, detecting differences smaller than ten percent would require sample sizes larger than thirty-five.

During the detailed data analysis following the site visits, the data will be analyzed to determine if the responses in each case study differ from the national data. Since the responses to all questions involve categorical data, non-parametric test statistics will be used. For questions with dichotomous answers, Fisher's exact test will be used.[7] For questions with ordered ordinal responses, a mean score statistic,[8] calculated with standardized midranks[9] will be used.

In addition, the data will also be analyzed across case studies. Dichotomous questions will be evaluated using the Mantel-Haenszel chi-square test.[10] Questions with ordered data will again be evaluated using a mean score statistic.

In this study, the results for a case will be considered to be meaningfully different from the national data if five or more of the twenty questions with national data, have results that are statistically different from the national data.

F.8 Data

A frequency table for each question is provided below. The table lists the raw data for each response together with its percentage of the total responses. Below the frequency table, the test statistic for each case study is shown. Finally, a test statistic for all of the data is provided.

[7] Gary G. Kock and Suzanne Edwards, "Clinical Efficacy Trials with Categorical Data," Chapter 9 in Biopharmaceutical Statistics for Drug Development, ed. Karl E. Peace, (New York, NY: Marcel Dekker, 1988), 409.

[8] Ibid., 411-413.

[9] In the SAS procedure FREQ, standardized midrank scores are referred to as modified ridits.

[10] Kock and Edwards, 416-417.

Question 1 - Is the condition of the environment:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Getting worse	Staying the same	Getting better	Don't know	Total
USATODAY	**550**	220	58	22	850
	64.7%	*25.8%*	*6.8%*	*2.5%*	
LASC	14	20	**29**	1	64
	21.8%	*31.2%*	***45.3%***	*1.5%*	
P&W	21	17	**33**	0	71
	29.5%	*23.9%*	***46.4%***	*.0%*	
LFWC	8	**17**	7	2	34
	23.5%	***50.0%***	*20.6%*	*5.9%*	
MDC	21	32	**37**	2	92
	22.8%	*34.8%*	***40.2%***	*2.2%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	62.075	0.000
LFWC - USATODAY	Row Mean Scores Differ	1	25.075	0.000
MDAE - USATODAY	Row Mean Scores Differ	1	77.887	0.000
P&W - USATODAY	Row Mean Scores Differ	1	50.429	0.000
ALL DATA	Row Mean Scores Differ	4	166.014	0.000

Table F.1. Data & Statistics for Question 1.

Question 2 - How worried are you about the environment?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Very worried	Somewhat worried	Not very worried	Not worried	Don't know	Total
USATODAY	292	**414**	85	54	19	864
	33.8%	***47.9%***	*9.8%*	*6.2%*	*2.2%*	
LASC	19	**36**	7	1	1	64
	29.6%	***56.2%***	*10.9%*	*1.5%*	*1.5%*	
P&W	18	**43**	10	0	0	71
	25.3%	***60.5%***	*14.1%*	*0.0%*	*0.0%*	
LFWC	6	**27**	1	0	0	34
	17.6%	***79.4%***	2.9%	*0.0%*	*0.0%*	
MDC	23	**53**	15	1	0	92
	25.0%	***57.6%***	*16.3%*	*1.1%*	*0.0%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.000	0.999
LFWC - USATODAY	Row Mean Scores Differ	1	0.090	0.764
MDAE - USATODAY	Row Mean Scores Differ	1	0.827	0.363
P&W - USATODAY	Row Mean Scores Differ	1	0.199	0.655
ALL DATA	Row Mean Scores Differ	4	1.077	0.898

Table F.2. Data & Statistics for Question 2.

Question 3 - How often--conversations about the environment?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Once a day	Once a week	Once a month	< one a month	Never	Don't know	Total
USATODAY	97 *11.4%*	**336** ***39.5%***	238 *28.0%*	94 *11.1%*	83 *9.7%*	2 *0.2%*	850
LASC	10 *15.6%*	**23** ***35.9%***	11 *17.1%*	16 *25.0%*	2 *3.1%*	2 *3.1%*	64
P&W	6 *8.4%*	**27** ***38.0%***	23 *32.3%*	13 *18.3%*	2 *2.8%*	0 *0.0%*	71
LFWC	8 *23.5%*	8 *23.5%*	**12** ***35.3%***	5 *14.7%*	0 *0.0%*	1 *2.9%*	34
MDC	11 *12.0%*	29 *31.5%*	**33** ***35.9%***	15 *16.3%*	1 *3.3%*	3 *1.1%*	92

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.017	0.897
LFWC - USATODAY	Row Mean Scores Differ	1	0.396	0.529
MDAE - USATODAY	Row Mean Scores Differ	1	0.378	0.538
P&W - USATODAY	Row Mean Scores Differ	1	0.197	0.657
ALL DATA	Row Mean Scores Differ	4	0.992	0.911

Table F.3. Data & Statistics for Question 3.

Question 4a - Do you consider yourself to be an environmentalist?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Don't know	Total
Gallup	**893** / ***72.9%***	294 / *24.0%*	37 / *3.0%*	1224
LASC	**32** / ***50.0%***	29 / *45.3%*	3 / *4.6%*	64
P&W	**45** / ***63.3%***	21 / *29.5%*	5 / *7.0%*	71
LFWC	**21** / ***61.8%***	11 / *32.4%*	2 / *5.9%*	34
MDC	**50** / ***54.9%***	37 / *40.7%*	4 / *4.4%*	91

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.000
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			0.218
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.000
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.193
ALL DATA	MH Chi-Square	8	25.790	0.000

Table F.4. Data & Statistics for Question 4a.

Question 4b - Environmentalist--Are you a strong environmentalist?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Don't know	Total
Gallup	428	**465**	0	893
	47.9%	***52.1%***	*0.0%*	
LASC	9	**18**	4	31
	29.0%	***58.1%***	*12.9%*	
P&W	6	**35**	2	43
	13.9%	***81.4%***	*4.6%*	
LFWC	3	**16**	2	21
	14.3%	***76.2%***	*9.5%*	
MDC	9	**32**	8	49
	18.4%	***65.3%***	*16.3%*	

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.171
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			0.000
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.001
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.000
ALL DATA	MH Chi-Square	8	61.199	0.000

Table F.5. Data & Statistics for Question 4b.

Question 5 - Government worry about the environment?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Not enough	About right	Too much	Don't know	Total
Gallup	**917**	220	37	49	1223
	74.9%	*17.9%*	*3.0%*	*4.0%*	
LASC	19	6	**36**	3	64
	29.6%	*9.3%*	***56.2%***	*4.6%*	
P&W	17	11	**37**	6	71
	23.9%	*15.4%*	***52.1%***	*8.4%*	
LFWC	**17**	4	13	0	34
	50.0%	*11.8%*	*38.2%*	*0.0%*	
MDC	20	13	**52**	6	91
	21.7%	*14.1%*	***56.5%***	*6.5%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Row Mean Scores Differ	1	85.536	0.000
LFWC - GALLUP	Row Mean Scores Differ	1	14.775	0.000
MDAE - GALLUP	Row Mean Scores Differ	1	151.453	0.000
P&W - GALLUP	Row Mean Scores Differ	1	113.338	0.000
ALL DATA	Row Mean Scores Differ	4	287.321	0.000

Table F.6. Data & Statistics for Question 5.

Question 6 - Business and Industry worry about the environment?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Not enough	About right	Too much	Don't know	Total
Gallup	**1040** *83.2%*	135 *10.8%*	37 *2.9%*	37 *2.9%*	1249
LASC	13 *20.3%*	4 *6.2%*	**45** ***70.3%***	2 *3.1%*	64
P&W	7 *9.8%*	2 *2.8%*	**56** ***78.8%***	6 *8.4%*	71
LFWC	11 *32.4%*	0 *0.0%*	**22** ***64.7%***	1 *2.9%*	34
MDC	18 *19.6%*	2 *2.2%*	**69** ***75.0%***	2 *2.2%*	91

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Row Mean Scores Differ	1	177.557	0.000
LFWC - GALLUP	Row Mean Scores Differ	1	70.280	0.000
MDAE - GALLUP	Row Mean Scores Differ	1	243.381	0.000
P&W - GALLUP	Row Mean Scores Differ	1	261.889	0.000
ALL DATA	Row Mean Scores Differ	4	526.205	0.000

Table F.7. Data & Statistics for Question 6.

Question 7 - Your company's worries about the environment

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Not enough	About right	Too much	Don't know	Total
LASC	**30**	4	24	6	64
	46.8%	*6.2%*	*37.5%*	*9.3%*	
P&W	**45**	3	15	8	71
	63.3%	*4.2%*	*21.1%*	*11.2%*	
LFWC	**26**	2	6	0	34
	76.5%	*5.9%*	*17.6%*	*0.0%*	
MDC	**54**	4	27	7	92
	58.7%	*4.3%*	*29.3%*	*7.6%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
ALL DATA	Row Mean Scores Differ	3	7.883	0.049

Table F.8. Data & Statistics for Question 7.

Question 8 - Keeping the env clean, how does the Federal Gvmt rate?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Excellnt	Good	Fair	Poor	Don't know	Total
USATODAY	5 *0.5%*	101 *11.8%*	**407** ***47.8%***	310 *36.4%*	27 *3.1%*	850
ASC	0 *0.0%*	13 *20.3%*	21 *32.8%*	**29** ***45.3%***	1 *1.5%*	64
P&W	0 *0.0%*	8 *11.2%*	**40** ***56.3%***	19 *26.7%*	4 *5.6%*	71
LFWC	0 *0.0%*	5 *14.7%*	**22** ***64.7%***	5 *14.7%*	2 *5.9%*	34
MDC	0 *0.0%*	9 *9.8%*	**52** ***56.5%***	30 *32.6%*	1 *1.1%*	92

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.015	0.902
LFWC - USATODAY	Row Mean Scores Differ	1	3.091	0.079
MDAE - USATODAY	Row Mean Scores Differ	1	0.517	0.472
P&W - USATODAY	Row Mean Scores Differ	1	0.443	0.505
ALL DATA	Row Mean Scores Differ	4	3.816	0.432

Table F.9. Data & Statistics for Question 8.

Question 9 - Keeping the env clean, how do US corporations rate?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Excellnt	Good	Fair	Poor	Don't know	Total
USATODAY	9 *1.1%*	120 *14.1%*	**372** ***43.7%***	330 *38.8%*	19 *2.2%*	850
LASC	0 *0.0%*	4 *6.2%*	**34** ***53.1%***	26 *40.6%*	0 *0.0%*	64
P&W	0 *0.0%*	9 *12.6%*	**34** ***47.8%***	26 *36.6%*	2 *2.8%*	71
LFWC	0 *0.0%*	5 *14.7%*	**18** ***52.9%***	11 *32.4%*	0 *0.0%*	34
MDC	0 *0.0%*	7 *7.6%*	**47** ***51.1%***	38 *41.3%*	0 *0.0%*	92

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.344	0.557
LFWC - USATODAY	Row Mean Scores Differ	1	0.676	0.411
MDAE - USATODAY	Row Mean Scores Differ	1	0.428	0.513
P&W - USATODAY	Row Mean Scores Differ	1	0.006	0.939
ALL DATA	Row Mean Scores Differ	4	1.565	0.815

Table F.10. Data & Statistics for Question 9.

Question 10 - In keeping the env clean, how do you rate yourself?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Excellnt	Good	Fair	Poor	Don't know	Total
USATODAY	93 *10.9%*	**401** ***47.1%***	317 *37.2%*	35 *4.1%*	4 *0.4%*	850
LASC	6 *9.3%*	**31** ***48.4%***	21 *32.8%*	6 *9.3%*	0 *0.0%*	64
P&W	8 *11.2%*	**41** ***57.7%***	20 *28.1%*	1 *1.4%*	1 *1.4%*	71
LFWC	3 *8.8%*	**20** ***58.8%***	10 *29.4%*	1 *2.9%*	0 *0.0%*	34
MDC	4 *4.3%*	**52** ***56.5%***	36 *39.1%*	0 *0.0%*	0 *0.0%*	92

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.207	0.649
LFWC - USATODAY	Row Mean Scores Differ	1	0.660	0.417
MDAE - USATODAY	Row Mean Scores Differ	1	0.005	0.943
P&W - USATODAY	Row Mean Scores Differ	1	2.380	0.123
ALL DATA	Row Mean Scores Differ	4	3.357	0.500

Table F.11. Data & Statistics for Question 10.

Question 11 - Opportunity you have to prevent pollution--community?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Great deal	Only some	Hardly any	Don't know	None	Total
LASC	9	**27**	26	2	0	64
	14.1%	***42.1%***	*40.6%*	*3.1%*	*0.0%*	
P&W	5	**50**	11	3	2	71
	7.0%	***70.4%***	*15.4%*	*4.2%*	*2.8%*	
LFWC	6	**21**	7	0	0	34
	17.6%	***61.8%***	*20.6%*	*0.0%*	*0.0%*	
MDC	8	**56**	27	0	1	92
	8.7%	***60.9%***	*29.3%*	*0.0%*	*1.1%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
ALL DATA	Row Mean Scores Differ	3	4.983	0.173

Table F.12. Data & Statistics for Question 11.

Question 12 - Opportunity you have to prevent pollution--company?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Great deal	Only some	Hardly any	None	Don't know	Total
LASC	7	23	**26**	7	1	64
	10.9%	*35.9%*	***40.6%***	*10.9%*	*1.5%*	
P&W	7	25	**30**	8	1	71
	9.8%	*35.2%*	***42.2%***	*11.2%*	*1.4%*	
LFWC	8	**17**	8	0	1	34
	23.5%	***50.0%***	*23.5%*	*0.0%*	*2.9%*	
MDC	4	33	**46**	8	1	92
	4.3%	*35.9%*	***50.0%***	*8.7%*	*1.1%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
ALL DATA	Row Mean Scores Differ	3	15.720	0.001

Table F.13. Data & Statistics for Question 12.

Question 13 - Company strongly supports efforts to prevent pollution?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Don't know	Total
LASC	19 *29.6%*	**27** ***42.1%***	6 *9.3%*	7 *10.9%*	5 *7.8%*	64
P&W	18 *25.3%*	**34** ***47.8%***	7 *9.8%*	3 *4.2%*	9 *12.6%*	71
LFWC	13 *38.2%*	**17** ***50.0%***	3 *8.8%*	0 *0.0%*	1 *2.9%*	34
MDC	19 *20.7%*	**44** ***47.8%***	15 *16.3%*	5 *5.4%*	9 *9.8%*	92

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
ALL DATA	Row Mean Scores Differ	3	5.095	0.165

Table F.14. Data & Statistics for Question 13.

Question 14 - Not much one person can do to help the environment:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Don't know	Total
USATODAY	118	174	226	**311**	21	850
	13.8%	*20.4%*	*26.5%*	***36.5%***	*2.4%*	
LASC	4	18	**24**	17	1	64
	6.2%	*28.1%*	***37.5%***	*26.5%*	*1.5%*	
P&W	4	22	**28**	16	1	71
	5.6%	*30.9%*	***39.4%***	*22.5%*	*1.4%*	
LFWC	1	**13**	10	10	0	34
	2.9%	***38.2%***	*29.4%*	*29.4%*	*0.0%*	
MDC	7	**32**	**32**	20	0	91
	7.7%	***35.2%***	***35.2%***	*22.0%*	*0.0%*	

Cochran-Mantel-Haenszel Statistics (Modified Ridit Scores)

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Row Mean Scores Differ	1	0.419	0.518
LFWC - USATODAY	Row Mean Scores Differ	1	0.451	0.502
MDAE - USATODAY	Row Mean Scores Differ	1	4.959	0.026
P&W - USATODAY	Row Mean Scores Differ	1	1.431	0.232
ALL DATA	Row Mean Scores Differ	4	6.434	0.169

Table F.15. Data & Statistics for Question 14.

Question 15 - People in environmental groups are most often:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Reason-able	Extrem-ist	Don't know	Total
CBSNews	**909**	409	106	1424
	63.8%	*28.7%*	*7.4%*	
LASC	**32**	22	10	64
	50.0%	*34.3%*	*15.6%*	
P&W	23	**33**	15	71
	32.3%	***46.4%***	*21.1%*	
LFWC	**19**	11	4	34
	55.9%	*32.4%*	*11.8%*	
MDC	**39**	35	15	89
	43.8%	*39.3%*	*16.9%*	

Data Included	Statistic	DF	Value	Prob
LASC - CBSNews	Fisher's Exact Test (2-Tail)			0.137
LFWC - CBSNews	Fisher's Exact Test (2-Tail)			0.551
MDAE - CBSNews	Fisher's Exact Test (2-Tail)			0.000
P&W - CBSNews	Fisher's Exact Test (2-Tail)			0.000
ALL DATA	MH Chi-Square	1	42.196	0.000

Table F.16. Data & Statistics for Question 15.

Question 16 - Env. standards cannot be too high--regardless of cost:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Agree	Disagree	Don't know	Total
CBSNews	**1121** ***76.3%***	318 *21.6%*	30 *2.0%*	1469
LASC	15 *23.4%*	**45** ***70.3%***	4 *6.2%*	64
P&W	22 *30.9%*	**39** ***54.9%***	10 *14.1%*	71
LFWC	5 *14.7%*	**24** ***70.6%***	5 *14.7%*	34
MDC	28 *30.4%*	**58** ***63.0%***	6 *6.5%*	92

Data Included	Statistic	DF	Value	Prob
LASC - CBSNews	Fisher's Exact Test (2-Tail)			0.000
LFWC - CBSNews	Fisher's Exact Test (2-Tail)			0.000
MDAE - CBSNews	Fisher's Exact Test (2-Tail)			0.000
P&W - CBSNews	Fisher's Exact Test (2-Tail)			0.000
ALL DATA	MH Chi-Square	1	253.727	0.000

Table F.17. Data & Statistics for Question 16.

Question 17 - Protect the environment even if it means higher taxes:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Agree	Disagree	Don't know	Total
CBSNews	**1076** / ***70.2%***	379 / *24.7%*	76 / *4.9%*	1531
LASC	**38** / ***59.3%***	24 / *37.5%*	2 / *3.1%*	64
P&W	**42** / ***59.1%***	23 / *32.3%*	6 / *8.4%*	71
LFWC	**18** / ***52.9%***	9 / *26.5%*	7 / *20.6%*	34
MDC	**50** / ***54.9%***	34 / *37.4%*	7 / *7.7%*	91

Data Included	Statistic	DF	Value	Prob
LASC - CBSNews	Fisher's Exact Test (2-Tail)			0.039
LFWC - CBSNews	Fisher's Exact Test (2-Tail)			0.383
MDAE - CBSNews	Fisher's Exact Test (2-Tail)			0.005
P&W - CBSNews	Fisher's Exact Test (2-Tail)			0.113
ALL DATA	MH Chi-Square	1	19.492	0.000

Table F.18. Data & Statistics for Question 17.

Question 18 - Protect env even if jobs in your community are lost:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Agree	Disagree	Don't know	Total
CBSNews	**848**	545	121	1514
	56.0%	*36.0%*	*7.9%*	
LASC	26	**27**	11	64
	40.6%	***42.1%***	*17.1%*	
P&W	**32**	25	14	71
	45.1%	*35.2%*	*19.7%*	
LFWC	**17**	11	6	34
	50.0%	*32.4%*	*17.6%*	
MDC	**43**	33	15	91
	47.3%	*36.3%*	*16.5%*	

Data Included	Statistic	DF	Value	Prob
LASC - CBSNews	Fisher's Exact Test (2-Tail)			0.088
LFWC - CBSNews	Fisher's Exact Test (2-Tail)			1.000
MDAE - CBSNews	Fisher's Exact Test (2-Tail)			0.471
P&W - CBSNews	Fisher's Exact Test (2-Tail)			0.491
ALL DATA	MH Chi-Square	1	15.897	0.000

Table F.19. Data & Statistics for Question 18.

Question 19 - In you company, too much time is spent on env. issues:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Agree	Disagree	Don't know	Total
LASC	1 *1.5%*	**50** ***78.1%***	13 *20.3%*	64
P&W	2 *2.8%*	**53** ***74.6%***	16 *22.5%*	71
LFWC	1 *2.9%*	**30** ***88.2%***	3 *8.8%*	34
MDC	1 *1.1%*	**75** ***81.5%***	16 *17.4%*	92

Data Included	Statistic	DF	Value	Prob
ALL DATA	MH Chi-Square	1	0.168	0.682

Table F.20. Data & Statistics for Question 19.

Question 20 - On this project, quality includes reducing pollution:

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Don't know	Total
LASC	**42** ***65.6%***	7 *10.9%*	15 *23.4%*	64
P&W	**38** ***53.5%***	14 *19.7%*	19 *26.7%*	71
LFWC	**27** ***79.4%***	1 *2.9%*	6 *17.6%*	34
MDC	**43** ***47.3%***	23 *25.3%*	25 *27.5%*	91

Data Included	Statistic	DF	Value	Prob
ALL DATA	MH Chi-Square	1	4.475	0.034

Table F.21. Data & Statistics for Question 20.

Question 21 - Boycotted a company's product--its record on the env?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Total
Gallup	342 *27.9%*	**881** ***72.0%***	1223
LASC	19 *29.6%*	**45** ***70.3%***	64
P&W	24 *33.8%*	**47** ***66.2%***	71
LFWC	11 *39.4%*	**20** ***60.6%***	33
MDC	18 *20.7%*	**69** ***79.3%***	87

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.776
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			0.418
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.171
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.281
ALL DATA	MH Chi-Square	1	0.000	0.987

Table F.22. Data & Statistics for Question 21.

Question 22 - Avoided buying a product because it was not recyclable?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Total
Gallup	**770** / ***62.9%***	453 / *37.0%*	1223
LASC	27 / *42.1%*	**37** / ***57.8%***	64
P&W	33 / *46.4%*	**38** / ***53.5%***	71
LFWC	**17** / ***51.5%***	16 / *48.5%*	33
MDC	**46** / ***51.1%***	44 / *48.9%*	90

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.001
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			0.203
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.032
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.000
ALL DATA	MH Chi-Square	1	19.449	0.000

Table F.23. Data & Statistics for Question 22

Question 23 - Voluntarily recycled newspapers, glass, aluminum, etc.?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Total
Gallup	**1040** / ***85.0%***	183 / *14.9%*	1223
LASC	**60** / ***93.7%***	4 / *6.2%*	64
P&W	**66** / ***92.9%***	5 / *7.1%*	71
LFWC	**33** / ***97.1%***	1 / *2.9%*	34
MDC	**90** / ***97.8%***	2 / *2.2%*	92

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.066
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			0.049
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.000
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.081
ALL DATA	MH Chi-Square	1	20.881	0.000

Table F.24. Data & Statistics for Question 23.

Question 24 - Did volunteer work for an environmental group?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Total
Gallup	220 *17.9%*	**1003** ***82.0%***	1223
LASC	15 *23.4%*	**49** ***76.5%***	64
P&W	10 *14.1%*	**61** ***85.9%***	71
LFWC	5 *15.6%*	**27** ***84.4%***	32
MDC	9 *9.8%*	**83** ***90.2%***	81

Data Included	Statistic	DF	Value	Prob
LASC - GALLUP	Fisher's Exact Test (2-Tail)			0.318
LFWC - GALLUP	Fisher's Exact Test (2-Tail)			1.000
MDAE - GALLUP	Fisher's Exact Test (2-Tail)			0.046
P&W - GALLUP	Fisher's Exact Test (2-Tail)			0.523
ALL DATA	MH Chi-Square	1	1.795	0.180

Table F.25. Data & Statistics for Question 24.

Question 25 - Contributed to an environmental group?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Yes	No	Don't know	Total
USATODAY	340 *40.0%*	**501** ***58.9%***	9 *1.1%*	850
LASC	29 *45.3%*	**35** ***54.6%***	0 *0.0%*	64
P&W	24 *33.8%*	**43** ***60.5%***	4 *5.6%*	71
LFWC	11 *32.4%*	**21** ***61.8%***	2 *5.9%*	34
MDC	37 *40.2%*	**55** ***59.8%***	0 *0.0%*	92

Data Included	Statistic	DF	Value	Prob
LASC - USATODAY	Fisher's Exact Test (2-Tail)			0.510
LFWC - USATODAY	Fisher's Exact Test (2-Tail)			0.583
MDAE - USATODAY	Fisher's Exact Test (2-Tail)			1.000
P&W - USATODAY	Fisher's Exact Test (2-Tail)			0.518
ALL DATA	MH Chi-Square	1	0.387	0.534

Table F.26. Data & Statistics for Question 25.

Question 26 - What is your occupation?

TABLE OF SOURCE BY ANSWER

Frequency / *Row Pct*	Manager	Engineer	Profess-ional	Admin or Clerical	Skilled foreman	Other	Total
LASC	8 *12.5%*	**46** ***71.8%***	7 *10.9%*	3 *4.6%*	0 *0.0%*	0 *0.0%*	64
P&W	7 *10.4%*	**47** ***70.1%***	5 *7.4%*	2 *2.9%*	4 *5.9%*	2 *2.9%*	67
LFWC	5 *14.7%*	4 *11.8%*	**14** ***41.2%***	3 *8.8%*	7 *20.6%*	1 *2.9%*	34
MDC	23 *25.3%*	**45** ***49.5%***	14 *15.4%*	9 *9.9%*	0 *0.0%*	0 *0.0%*	91

Table F.27. Data & Statistics for Question 26.

F.9 Factor Analysis Data

- - - - F A C T O R   A N A L Y S I S - - - -

Principal-Components Analysis
(Pairwise deletion of cases with missing values)

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
QUEST21	1.00000	*	1	3.43738	13.2	13.2
QUEST14	1.00000	*	2	2.86252	11.0	24.2
QUEST02	1.00000	*	3	1.88105	7.2	31.5
QUEST11	1.00000	*	4	1.69517	6.5	38.0
QUEST08	1.00000	*	5	1.36449	5.2	43.2
QUEST03	1.00000	*	6	1.25308	4.8	48.1
QUEST15	1.00000	*	7	1.20412	4.6	52.7
QUEST05	1.00000	*	8	1.05578	4.1	56.7
QUEST13	1.00000	*	9	.97104	3.7	60.5
QUEST01	1.00000	*	10	.93247	3.6	64.1
QUEST16	1.00000	*	11	.89002	3.4	67.5
QUEST06	1.00000	*	12	.87148	3.4	70.8
QUEST07	1.00000	*	13	.84993	3.3	74.1
QUEST09	1.00000	*	14	.83934	3.2	77.3
QUEST10	1.00000	*	15	.74614	2.9	80.2
QUEST04A	1.00000	*	16	.70420	2.7	82.9
QUEST12	1.00000	*	17	.60055	2.3	85.2
QUEST17	1.00000	*	18	.57655	2.2	87.4
QUEST18	1.00000	*	19	.52865	2.0	89.5
QUEST19	1.00000	*	20	.49292	1.9	91.4
QUEST20	1.00000	*	21	.47352	1.8	93.2
QUEST22	1.00000	*	22	.44021	1.7	94.9
QUEST23	1.00000	*	23	.40675	1.6	96.5
QUEST04B	1.00000	*	24	.38560	1.5	97.9
QUEST24	1.00000	*	25	.35846	1.4	99.3
QUEST25	1.00000	*	26	.17858	.7	100.0

PC Extracted 8 factors.

---- F A C T O R   A N A L Y S I S ----

Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization.

Rotated Factor Matrix: Varimax converged in 10 iterations.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
QUEST21	.61041	.07783	.00295	-.11148	.30145
QUEST14	-.32031	.01810	.05206	-.05561	.04274
QUEST02	.37003	.18429	.19009	.41888	.04623
QUEST11	-.07552	.11969	.3[illegible]127	.07774	.27798
QUEST08	.00976	-.12237	.54808	.03776	.02416
QUEST03	.07405	.05577	.08460	-.00568	.02131
QUEST15	.12172	-.06227	.17824	.21091	.07386
QUEST05	.07843	-.00709	.05641	.75675	.21389
QUEST13	-.03629	.20120	.18244	-.09240	.00903
QUEST01	.13435	-.00672	-.12133	.18976	.15229
QUEST16	.10662	-.04709	-.00621	-.01522	.63623
QUEST06	-.09112	.02406	-.16740	.74044	.12662
QUEST07	.02612	.08659	-.05500	.52873	.00051
QUEST09	-.00451	-.02034	.71107	-.18905	-.25543
QUEST10	.04183	.24756	.67010	-.04453	.03728
QUEST04A	.13153	.91505	.11823	.06612	.07550
QUEST12	-.14184	-.00035	.34754	-.08432	.18341
QUEST17	.08669	.02372	-.03605	.17636	.73635
QUEST18	.00359	.05528	-.04813	.12600	.64276
QUEST19	.22570	-.12989	.34318	.05098	.14702
QUEST20	.07061	-.05867	-.07861	-.06545	-.02823
QUEST22	.60420	.25973	.17822	.19648	-.05844
QUEST23	.70785	-.02976	-.02539	.06976	-.13631
QUEST04B	-.09813	-.90640	.01003	-.03296	.00237
QUEST24	.67310	-.04259	.10950	-.03706	.04018
QUEST25	.61651	.17974	-.24412	-.02396	.22689

	FACTOR 6	FACTOR 7	FACTOR 8
QUEST21	.01586	-.02368	.16897
QUEST14	-.00664	.65222	-.00362
QUEST02	.03119	.03757	.37859
QUEST11	.08502	-.47222	.22738
QUEST08	.21315	-.18927	-.39506
QUEST03	.09296	-.14153	.81236
QUEST15	.32121	.35003	.37106
QUEST05	-.14956	.16560	.03803
QUEST13	.73877	-.08168	-.11504
QUEST01	-.16917	.55778	.00006
QUEST16	-.16871	.28241	-.22478
QUEST06	-.17556	-.08858	-.13065
QUEST07	.38644	.05610	.16011
QUEST09	.09337	.04122	.02730
QUEST10	-.07127	-.09468	.12096
QUEST04A	.01833	-.01955	.02808
QUEST12	.45156	-.35636	.22676
QUEST17	.11857	.03697	.08153
QUEST18	.03560	-.09503	.08671
QUEST19	.35264	.21388	.18891
QUEST20	.6581[illegible]	-.09900	.09428
QUEST22	.06875	-.07092	.05624
QUEST23	-.00865	-.09076	-.13775
QUEST04B	-.05470	.02290	-.06365
QUEST24	-.05499	.06206	.10894
QUEST25	.13084	.08845	-.00627

APPENDIX G

INTERVIEW PLAN

G.1 Objectives

1. **How is pollution prevention implementation proceeding?**

2. **To what extent--and how--are the pollution prevention by design criteria being met?**

3. **What revisions, if any, to existing pollution prevention processes, procedures, and policy are needed to better meet the pollution prevention by design criteria?**

G.2 Interview Type -- Intensive Interviews

Approximately 20 individuals per program will be interviewed. The interviews will last between 30 minutes and 2 hours. Each interviewee will be asked all the questions in topics 1, 2, 3, 8, and 9. Coverage of topics 4, 5, 6, and 7 will depend on the degree of involvement the interviewee has with environmental issues. The overall research objectives are listed above. The interviews will provide one source of the information for addressing the questions. Additional information will come from documents, historical records, direct observation, and participant-observation. The primary goals of the interviews are to find out what (environmentally) is happening within each program, to determine how pollution prevention works (generally, and well as specifically in terms of the pollution prevention by design model), and to gather the interviewee's suggestions for improvement. A secondary goal is to briefly characterize the interviewee's beliefs and

behaviors on environmental issues. This information will be used to assess the general level of "environmentalism" among the people interviewed.

G.3 Topics to be Covered

1. Position, major responsibilities, and demographic data
2. System design and engineering -- Organizational relationships
3. System design and engineering -- Process
4. Administrative controls -- policies, procedures, standards, design handbooks
5. Information flows -- inputs, analyses conducted, outputs
6. Current pollution prevention practices
7. Decision making processes
8. Resources
9. Ideas for improvement

G.4 Lead Statement

Good morning (afternoon), I'm Roy Salomon from the University of North Carolina and I am working with the Air Force on pollution prevention in acquisition programs. As you read on the consent form, the Secretary of the Air Force and the Air Force Chief of Staff, jointly tasked each Air Force program manager with the goal of preventing future pollution by reducing the use of hazardous materials and the releases of pollutants into the environment to as near zero as feasible. I want to discuss how the challenge impacts the work you do.

Over the next hour or so, I would like to get an understanding of your job and major responsibilities, how operational and support issues are currently analyzed and used in decision making in your area of systems development, what role environmental issues play, and then finally, to discuss what changes to Air Force or company policies, procedures, processes, methods of analysis, training or other areas might be needed to help meet the Air Force's goal.

In order to enable you to speak freely and to tell me what you think, I want you to know that my conclusions from this interview will be presented in a way that prevents others from identifying the source. I will be taking notes during the interview but no quotes will be used unless you give permission following the interview. Before we begin, please read, and if you agree, sign this conscent form. . . (After the conscent is signed) Do you have any questions before we start?

G.5 Questions

G.5.1 <u>Topic 1 - Position, major responsibilities, and demographic data</u>

1. **Let's begin with your position--what are your major responsibilities?**

2. What is you job title?

3. How long have you been in your current position?
   a. less than six months
   b. six month to one year
   c. one to two years
   d. two to five years
   e. five to ten years
   f. more than ten years

4. How long have you been working for (company name)?
   a. less than six months
   b. six month to one year
   c. one to two years
   d. two to five years
   e. five to ten years
   f. more than ten years

5. Please tell me about your professional work history--past jobs and their major responsibilities?

6. Do you hold a college degree? Yes or No. If yes, what degrees do you hold?
   a. BS ______________________________
   b. MS ______________________________
   c. Ph.D. ______________________________

7. What kinds of specialized training have you received?

8. Was pollution prevention, waste minimization, or any other environmental topic included in the training? If so, please explain?

G.5.2 Topic 2 - System Design and Engineering - Organizational relationships

Lead - Let's go on to discuss system design and engineering. I would like to cover several aspects of the system development process here at ________.
(Need to add company specific introduction indicating that the interviewer understands the basic company organization and its version of concurrent engineering.)

9. Let's begin with the organizational structure--to whom do you report? (Name and title)

10. Who reports to you?

11. Who do you work with every day?

12. Briefly describe what role each of these people plays in getting the job done?

13. What teams, working groups, and committees do you belong to?

14. What is your role in each team?

15. Does anyone have responsibility for environmental issues in any of the groups? If so, please explain?

G.5.3 Topic 3 - System Design and Engineering - Process

Lead - Now let's lets talk about how the system design and engineering process, and how concurrent engineering is being applied to pollution prevention. To start, let's begin by talking about reducing the use of hazardous materials. I am interested in all efforts to reduce the amount or the toxicity of hazardous materials used in the system, during its manufacture, or during operations and maintenance.

16. Would you please describe how hazardous materials issues are being addressed in your area of the program?

17. What aspects of hazardous material use are important in your area? (toxicity, volume, on a priority list, level of potential impacts, etc.)
    a. What process was used to identify these issues?

18. What role do life cycle considerations play in identifying important issues?
    a. What life cycle issues were important?
    b. Please describe any analysis that is conducted on life cycle issues?

19. What variables were selected for consideration? (What issues are covered by design criteria?)
    a. What are the definitions of the variables?
    b. How were the definitions developed? (Who provided the definitions?)
    c. Are specific metrics being used to measure success? What are they?
    d. Where are they documented?

20. What are the design control procedures, design guidelines, specifications or other requirements that govern system development in your area?
    a. Which are the most important? Why?
    b. Can you provide a specific case where (answer from a.) impacts pollution prevention?
    c. How are trade-offs amoung system requirements made?
    d. Please provide an example of a typical trade-off in your area?
    e. What were the alternatives that were considered?

f. How were the alternatives identified? Who was involved?
g. What was the outcome?

21. How will the design be verified?
    a. What data on these metrics is, or will be, measured, or otherwise obtained?
    b. Will any testing be done? Please describe the tests?
    c. How will the test data be analyzed?
    d. How is the cost-effectiveness of the design considered?
    e. How are the results documented? Could you show me an example?
    f. How was this (naming the example) used in decision making?

22. What general principles, design verification methods, design guides, or other methods are being developed to standardize this process during system development?

23. Now let's change the focus from hazardous materials and discuss the full range of environmental issues. This includes things like air emissions, waste water, hazardous waste, environmental reporting requirements, and the whole range of environmental considerations. What other environmental issues have you addressed in your work? Please explain?

    Follow-up with questions 1-6 as needed.

G.5.4 Topic 4 - Administrative controls - policies, procedures, standards, handbooks

Lead - Let's now cover the standards that govern how you do your job. There are usually key policies, procedures, standards, contract provisions, design handbooks, or other guides that govern what must be done, to what specifications, and using particular analytical techniques.

24. Please describe the key standards that govern your work?

25. What environmental considerations do the standards include?
    a. How are the environmental considerations analyzed and used?

26. Have any technical disputes over the issues, the data, or its use occurred? Please describe the situation?
    a. How was the dispute resolved?
    b. Who was involved?
    c. What was decided?
    d. What was the key to the decision that was reached?

27. Is there a process for outside review? Describe the process.
    a. Please provide an example of how this works?

28. Do the standards contain barriers to effective consideration of environmental impacts? How so?

29. How could environmental impacts be better considered in the process?

G.5.5 Topic 5 - Information flows - inputs, analyses conducted, outputs

Lead - Now let's discuss information flows. Let's start by looking at you as the receiver of information.

30. What information related to environmental issues do you receive now?

31. By what means do you get it?

32. What additional information do you need to receive?
   a. By what means you like to get it? From whom?
   b. Why aren't you getting it now?
   c. What should top management be communicating that they are not?

33. What kinds of information do you need to know is available but not necessarily to receive all the time? How should it be made available?

34. Now let's discuss you as the sender of information. Do you send any information that is related to environmental issues? What?
   a. How do you know what to send?
   b. How do make the decision to initiate communication?
   c. Do you find yourself requesting information on environmental issues to do your job. What kind?
   d. Does the information you send get to the get the people who need it?
   e. Who are they? What do they need it for?
   f. When there are blocks to communication, what do you do?
   g. Does someone review and amend it? Who?

35. Are there important differences for you between communicating with others at __________ and communicating with the Air Force Program Office? Please explain?

G.5.6 Topic 6 - Decision making processes

Lead - Now let's discuss how conflicting system requirements are balanced.

36. Please provide an example of a decision that you were involved in that required an environmental requirement to be balanced with other system requirements? Please describe the situation.

37. Who else was involved?

38. How was the environmental issue characterized--qualitatively or quantitatively? Please explain.

39. Was there adequate information?

40. Was the decision reviewed by management. Who and how?

G.5.7 Topic 7 - Resources

Lead - Now let's discuss the resources that are available for accomplishing your job including time, people, equipment, and funding.

41. Overall, which resource constraint presents the greatest challenge? Please provide a specific example.

42. How do resource constraints have an impact on your consideration of environmental issues?

43. What additional resources do you need?
    a. How would you characterize the impact of not having the additional resources you need?

G.5.8 Topic 8 - Ideas for improvement

Lead - Finally, let's discuss how consideration of environmental issues could be improved.

44. What steps would you recommend?

45. Why should this done? What is the payoff?

46. Have you observed any unanticipated effects from considering environmental issues--desirable or undesirable? What is it? Why do you think it happened?

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